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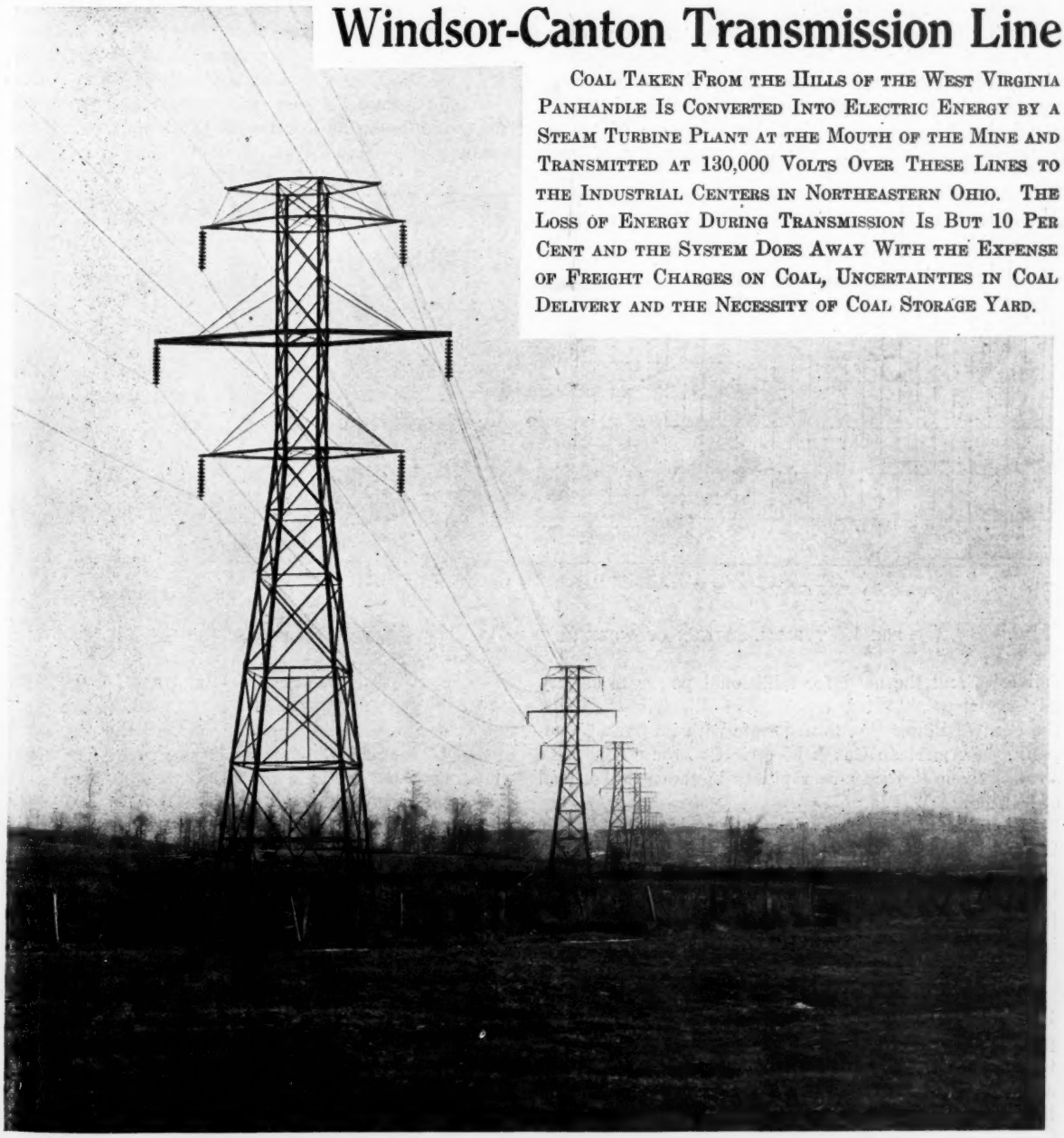
Windsor-Canton Transmission Line

COAL TAKEN FROM THE HILLS OF THE WEST VIRGINIA PANHANDLE IS CONVERTED INTO ELECTRIC ENERGY BY A STEAM TURBINE PLANT AT THE MOUTH OF THE MINE AND TRANSMITTED AT 130,000 VOLTS OVER THESE LINES TO THE INDUSTRIAL CENTERS IN NORTHEASTERN OHIO. THE LOSS OF ENERGY DURING TRANSMISSION IS BUT 10 PER CENT AND THE SYSTEM DOES AWAY WITH THE EXPENSE OF FREIGHT CHARGES ON COAL, UNCERTAINTIES IN COAL DELIVERY AND THE NECESSITY OF COAL STORAGE YARD.



Windsor-Canton Transmission Line

LONG DISTANCE TRANSMISSION of energy has become possible only within the last generation, and a great step forward has recently been made by the American Gas and Electric Co., which develops electric energy at the coal mines in West Virginia and transmits it at high voltage to the industrial center around Canton, O., a distance of nearly 60 mi. This development is not new in principle, neither does it present problems new to engineering practice, but it does on a large scale what heretofore has been accomplished only in a comparatively small way.

During recent years industrial centers depending upon coal for fuel, which is shipped in from some distant mining districts, have, as a matter of insurance, been compelled to carry great supplies of coal on hand to guard themselves against shut down in case of transportation difficulties. It was this uncertainty of coal deliveries and the need for additional power to supply its customers that led the Canton Electric Co., now the Central Power Co., to negotiate with its parent company, the American Gas & Electric Co., for power from steam driven electric power plants in the neighborhood of Wheeling, W. Va.

For a number of years The Sunnyside Electric Co. has been distributing power from Wheeling to various mines and towns in the neighborhood. So successful has the enterprise been that additional generating capacity was found necessary for the development of the industry.

With The Sunnyside Electric Co. as nearby consumers and Canton at a distance, the American Gas & Electric Co. has pushed the construction of an immense power plant, transmission line and substation almost to completion in a little more than a year. In this article we will take up a description of the transmission line.

Line Construction

On the east bank of the Ohio River, at Windsor, a few miles north of Wheeling, is located the power plant which will furnish the electric energy for this great transmission and distribution system. It is in the heart of an almost unlimited coal field, in fact, at the very mouth of an immense coal mine from which its supply will be drawn. The energy generated here will be transformed to 130,000 v. by transformers located in an outdoor switch yard. Cables lead to an anchor tower in the switch yard, then direct to a suspension tower, designated as No. 1, where the transmission line really begins.

As a fitting start in its field of service to man, this mighty energy that has lain dormant in the West Virginia hills for ages is shot at lightning speed to the top of a 165-ft. tower, across that picturesque yet industrious, complacent and docile yet at times turbulent and unmanageable Ohio River, climbing steep rocky hills,

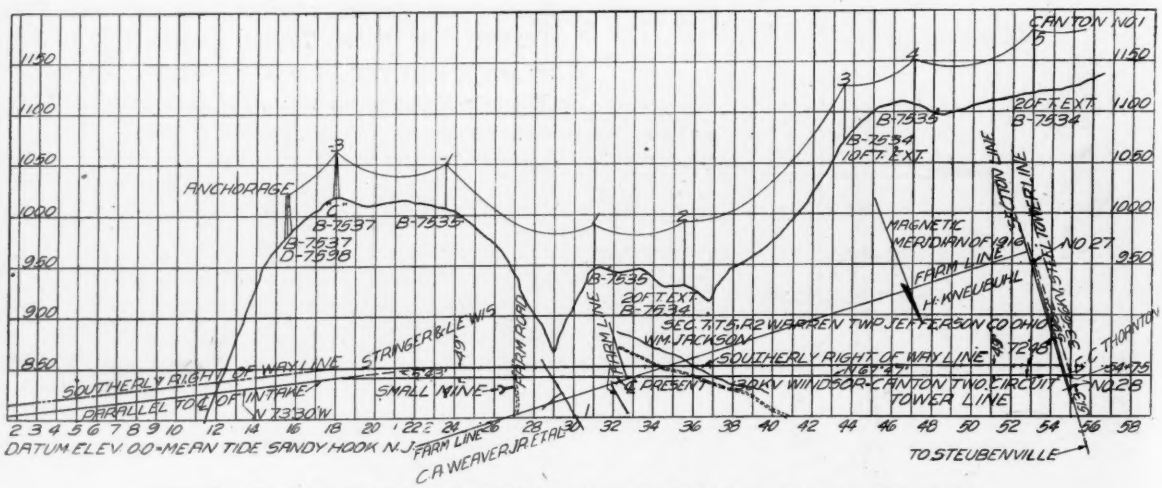


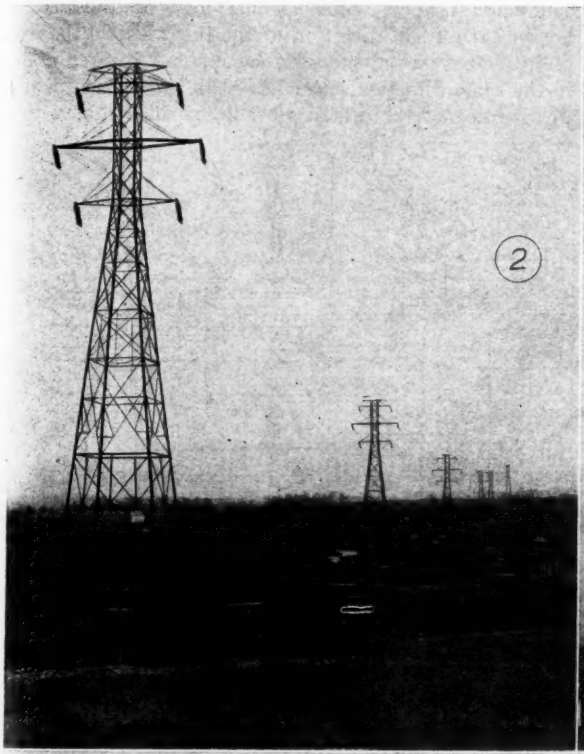
FIG. 1. TYPICAL SECTION OF WORKING MAP AND PROFILE, WINDSOR-CANTON LINE

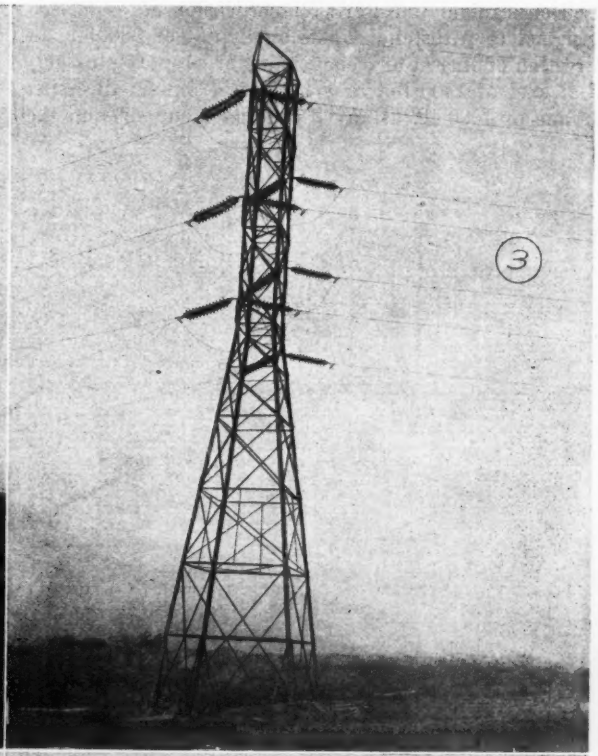
down over fertile valleys, through farm lands, woodlands, towns and villages to a city teeming with industry, there to serve its master, man, at the touch of a button to perform wonders undreamt of by our fathers who fought the Indians and cleared the forests of this great section of our country.

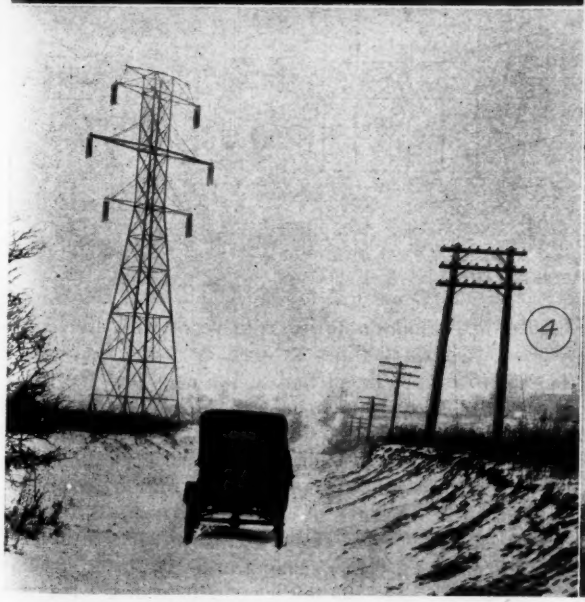
Tower No. 1 is 168 ft. high above the foundation which is of concrete, approximately 20 ft. above ground and 40 ft. deep. Tower No. 2 is of similar construction and height, while No. 3 is of the anchor type. From tower No. 1 on the West Virginia side to No. 2 on the Ohio side of the river is 1500 ft., from No. 2 to No. 3 is 1482 ft. These towers carry the two, 130,000-v., 3-phase, 60-cycle circuits consisting of six 200,000-c.m. phosphor bronze transmission cables hung on suspension type insulators, and two phosphor bronze 200,000-c.m. ground wires. Low water clearance over the river is 110 ft.; high water, 61 ft. 3 in., which precludes the liability of damage to transmission line during floods. Other

parts of the line have a minimum clearance of 28 ft. from the ground.

In the regular transmission line construction six 200,000-c.m. copper cables and two 7-strand galvanized ground wires are used; the latter are mounted on the top of the towers 8 ft. above the upper cross arm on the angle and strain towers, and 4 ft. above on the suspension structures. Suspension type insulators made by the Ohio Brass Co., according to the design of the American Gas & Electric Co., are used throughout. These insulators are used 10 disks in series in straight suspension and 12 on all tension points at long spans, railroad crossings, important roads, telephone lines and at other points; where it is necessary special steel yokes are used for double, triple or quadruple string tension assembly. At other important crossings double suspen-







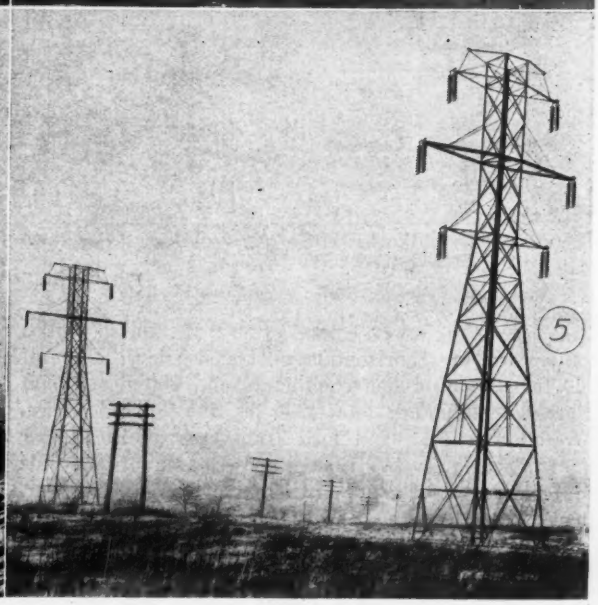


FIG. 2. 125-FT. TYPE B STRUCTURES

FIG. 3. DEAD END TOWER, TYPE C STRUCTURE, ENTERING CANTON SUBSTATION

FIG. 4. STANDARD ROAD CROSSING

FIG. 5. STANDARD CROSSING OVER LONG LINES OF THE TELEPHONE CO.

sion and semi-tension assemblies are used. An interesting detail is the horn gap provided around insulators on anchor towers to prevent the breakdown of insulators during lightning storms. The gap is 3 ft. 8 in., and the arrangement is shown in an accompanying illustration.

Three types of towers, known as A, B, and C, built by the American Bridge Co.'s Tower Department, are used in the main line construction. Type A towers are used on straight line work for suspension only and are designed to withstand a horizontal pull of 5800 lb. in direction of line at any one conductor support plus vertical load of 1500 lb.; or a horizontal pull in direction of line of 4000 lb. at any 2 conductor supports on the same side of the tower, a total of 8000 lb., due to broken conductors; or a horizontal pull transverse with line of 600 lb. at 6 unbroken conductors and 300 lb. each at 2 broken conductors, total 4200 lb., due to wind on ice-covered wires; a wind load transverse of 15 lb. per sq. ft., acting at 1½ times exposed area of one side equivalent to 35 lb. per ft. height of tower; or a vertical load of 1000 lb. at each of 8 wire supports.

The type B will sustain a horizontal pull of 1000 lb. at each of 6 unbroken conductors and 500 lb. at each of 2 broken conductors in excess of the requirements of type A; weight on towers: A, 10,300 lb.; B, 11,500 lb.; height of towers: A and B above ground, 78 ft.; height of tower extensions, 10 ft. and 20 ft.; number and size of footings, 4—4 in. by 3 ft. Set: B, 8 ft. 6 in.; A, 7 ft. 6 in.; length of center arms, 31 ft. 9 in.; length of upper arms, 21 ft. 9 in.; length of lower arms, 21 ft. 9 in.; spacing of arms, 12 ft.; the cross arms and footings on all towers are galvanized.

Type C are strain or anchor towers. They are designed to carry six 200,000 c.m., two ⅜-in. steel ground wires, dead ends and angles up to 45 deg.; horizontal pull of 5800 lb. in direction of line on any conductor support, plus vertical load of 1500 lb.; a horizontal pull in direction of the line of 4000 lb. from each of any 3 conductors on same side of tower acting in the same direction, total 12,000 lb.; a horizontal pull in direction of the line of 4000 lb. on all 8 cables, total 32,000 lb.; wind on tower transverse with line 15 lb. per sq. ft. on 1½ times exposed area one side equivalent to 45 lb. per lineal foot of the height of the tower; a vertical load of 1000 lb. on each of the 8 wire supports; weight of tower 17,000 to 22,000 lb.; height of tower above ground, 80 ft.; height of extensions, 10 ft. and 20 ft.; number and size of footings, four 6 ft. by 6 ft. set 9 ft. 6 in. Length of center cross arm, 31 ft. 9 in.; length of upper cross arm, 21 ft. 9 in.; length of lower cross arm, 21 ft. 9 in.; spacing arms 12 ft.

In all there are 503 tower structures in the transmission line extending a total distance of 55.6 mi., the first 30 mi. of which is over extremely broken surface; the rest of the way is rolling surface which is ideal for

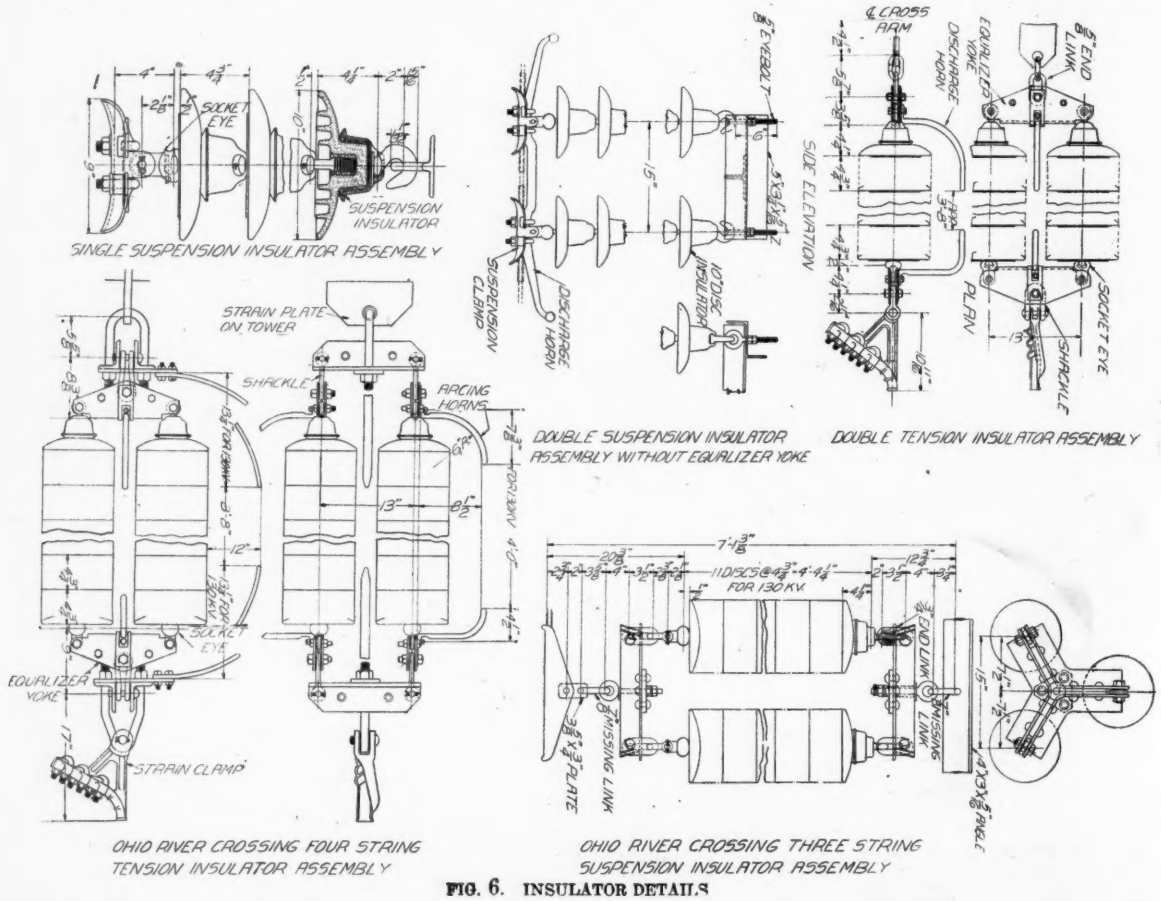


FIG. 6. INSULATOR DETAILS

tower construction. The lengths of spans vary from 250 to 1500 ft., with an average of 583 ft. The right of way over the Ohio River is 600 ft. wide, but along the transmission line it is 150 to 200 ft. wide.

Handling Materials

Handling the materials for the transmission line during construction was one of the interesting engineering problems encountered. This work was in charge of M. P. Kerr and his methods are briefly described as follows:

In order to unload and handle the material efficiently, all like members of the towers were loaded on the cars together, making them accessible, material for 3 mi. being loaded on from 4 to 5 cars. These cars were placed one ahead of another and the teams pulled in alongside of them in order, some loading long members, some medium length, and still others loading the shorter ones. These wagons were loaded in weight according to the physical condition of the country they had to go over, one tower taking from 3 to 7 wagons to complete its delivery. In all, about 6,183,500 lb. or 100 60,000-lb. cars of steel were handled.

As the wagons were loaded and they reached the field, hauling on an average of about 3 mi., the field directors took up the work. The placing of the material at the stake must be absolutely correct in order to eliminate the cost of labor by any unnecessary handling of the steel by the assembling crew.

The anchorage was placed in pile No. 1 about 15 ft. from the stake and ahead of it piles No. 2, No. 3, No. 4 and No. 5, consecutively. Pipe No. 2 was the bottom legs or section, pile No. 3 the middle legs or section and so on. This arrangement allowed the assembling crew simply to block up and bolt together each succeeding section. According to the elevation of the ground, the members were either laid parallel or at right angles to the line of survey. Railroad crossings and telephone lines also governed this condition.

On the insulator, hardware and wire distributing gang, 5 teams, 12 men and a Jeffrey 4-wheel drive truck with 2 trailers were used. Transmission wire came in 1-mi. reels, weighing 3220 lb. per reel; 324 mi. in all; ⅜-in. 7-strand steel wire on 1-mi. reels was used for the 2 ground wires, making 108 mi. of it. A total of 1,205,280 lb. of wire.

Insulator materials were easier to handle than the tower distribution, but care was exercised in checking the material at each tower in order not to delay the insulator and wire stringing gangs. The long hauls from the receiving points to the points where the teams pick up the material were made with the truck and trailers, resulting in a great saving of time that would be lost if only teams were used.

The specified kind and number of insulators and clamps were hauled to each tower and placed within its base, being checked when taken off the wagons, as well as when put on.

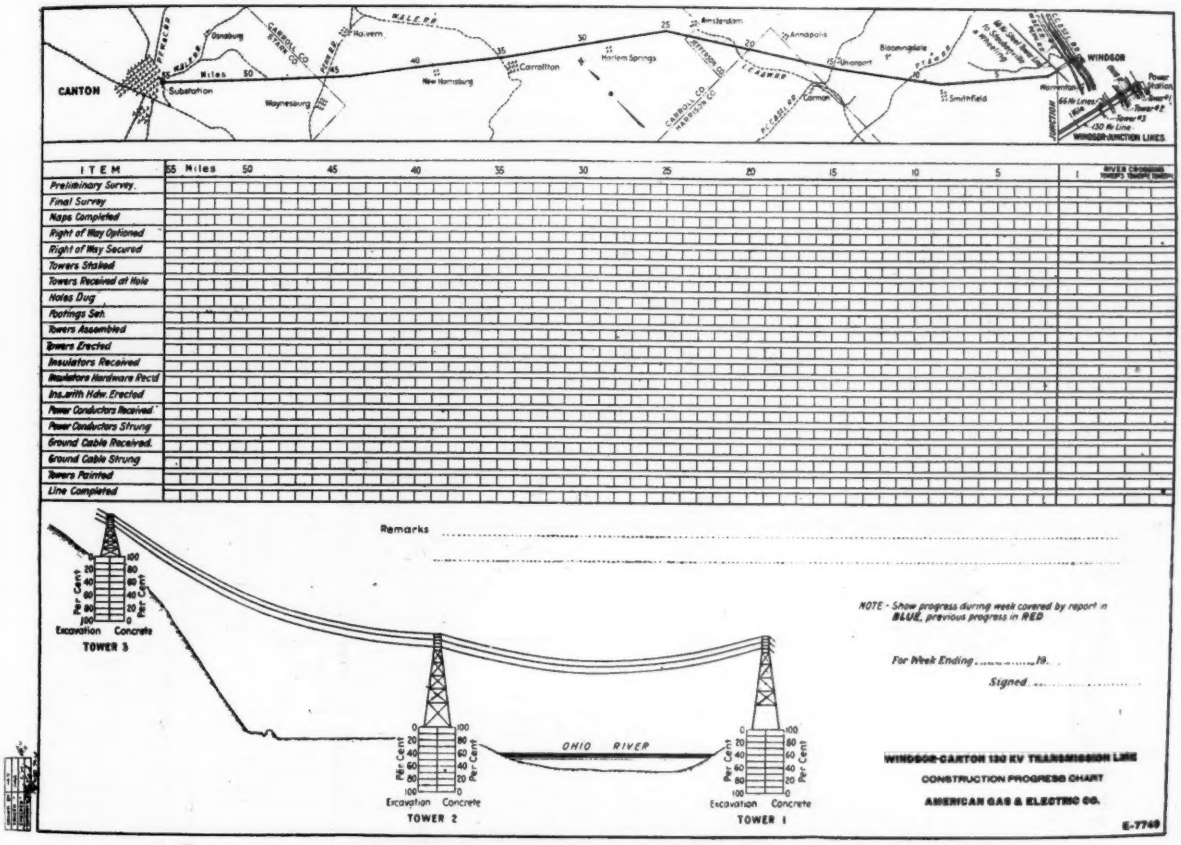


FIG. 7. BLANK PROGRESS CHART USED DURING CONSTRUC TION OF WINDSOR-CANTON LINE

Starting at the Ohio River end of the line, set-ups were made every 5250 ft., allowing 30 ft. for sag. If possible these set-ups were made on the high points to enable the handling as well as being able to detect the signaling more plainly.

As the reels were emptied, they were gathered up and hauled ahead to the next receiving point and shipped back for credit, thus saving a clean-up gang coming back for this purpose.

In order to keep in active touch with this work of the material department, the material man covered from 75 to 100 mi. every day in a Ford car.

Each tower has 4 footings; these are of galvanized steel of patented design, each set in a block of concrete 6 ft. square and 9½ ft. in the ground. The footings were set by templet, the towers assembled on the ground and then erected by means of an A-frame gin pole. The transmission line and construction was in charge of F. W. Abbot, vice-president and construction manager, and Frank Howard, general superintendent.

A description of the Canton Substation will be published in the April 1 issue.

Feed Water Control--III

Details of an Expansion Type Regulator and Alarm Columns

OPERATION of the Cade feed water regulator is as follows: When water in the water column falls below the middle try cock, steam flows to the expansion tube, shown in Fig. 11, by way of pipe *j*. The expansion tube, being subjected to the temperature of the steam, expands and increases in length, which causes the tube to rise on the yoke, *p*, due to the tendency of the strap, *b*, to straighten upon the lengthening of the tube. At the same time, the strap, *c*, rises, due to straightening out on the headers at the ends of the tube. The combined upward movements of the expansion tube with its headers and the strap, *c*, bring the lower strap, *e*, in engagement with the valve-stem guide cap which opens valve *f* and allows feed water to flow into the boiler, and at the same time raises lever arm *x* with its weight, *w*.

This regulator, which is manufactured by the H. E. Cade Co., of Philadelphia, Pa., is designed to operate above the normal level of the boiler, and the valve of the regulator is installed in the feed water line at some convenient location above the water level and not too far from the water column.

High and Low Water Alarms

More boiler injuries are attributed to low water than to any other one cause. That an abnormally low water line is a serious menace to the safety of the boiler hardly requires proof, knowing that when a surface subject to the direct action of the fire or of very hot gases is uncovered by water, its temperature may rise almost to that of the fire itself. Inasmuch as iron or steel lose most of

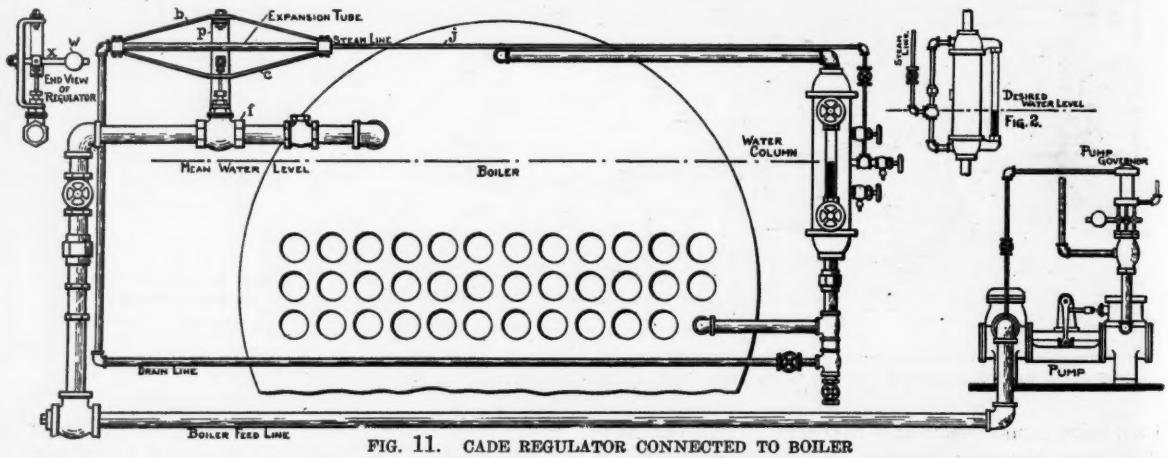


FIG. 11. CADE REGULATOR CONNECTED TO BOILER

Water continues to rise until it reaches the middle try cock, when steam to the expansion tube is sealed by the water in the column, closing the opening to the pipe, *j*. This causes the steam in the expansion tube to condense and a resultant siphoning of water into the expansion tube, which, upon cooling, contracts, lowering the expansion tube and the strap, *c*, and allows the weight, *w*, acting through the lever arm, *x*, to close the feed line.

Strap *c* is loose upon the valve stem and any desired opening can be obtained by an adjustment of the guide cap on the valve stem. By lowering the guide cap a greater lift will be had on the valve, and vice versa, by raising it, a smaller lift will result.

their tensile strength above 1000 deg. F., it is not surprising that under these conditions bags or pockets are formed in the plates, or tubes give way entirely. Even if this does not happen, the uneven heating of parts of the shell and tubes subjects them to stresses that are apt to start the seams and tube ends or to overstrain the metal.

High water level also has its subsequent dangers. Steam rising from the surface of the water usually carries with it a considerable amount of water, but if ample steam storage room is provided, the water will have time to drop back again before the steam leaves the drum. As the general practice of firemen with a manually con-

trolled boiler feed is to feed water until the level is considerably above normal before shutting off the valve, the steam space is reduced, and enough water may be carried out with the steam to bring about disastrous results.

Water carried out with the steam may produce water hammer and rupture the steam piping and fittings; it may burst a cylinder head or bend the connecting and piston rods. In steam turbines, considerable masses of water in the steam result in the stripping of the rotor blades. Even if water is not carried over with the steam, an abnormally small steam space usually results in continual priming, which gives wet steam and seriously interferes with the efficient operation of both steam engine and turbine.

Many methods have been devised for sounding an alarm when the water level reached a certain point above or below the normal position. Usually a float is fitted in the water column which in rising or falling to a predetermined level unseats a valve connected to a whistle pipe. In some cases, two whistles are employed, one sounding the high water alarm, while the other, with a different tone, indicates low water, while some alarms indicate low water only.

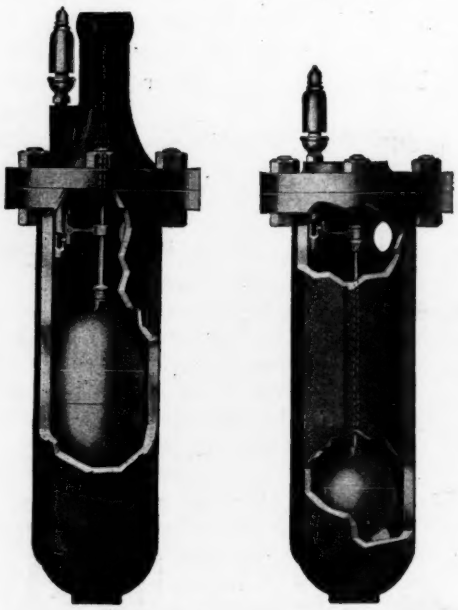


FIG. 12. ELLIOTT HIGH AND LOW WATER ALARM COLUMN

FIG. 13. ELLIOTT LOW WATER ALARM COLUMN

Elliott Water Column Alarms

A GENERAL ARRANGEMENT of the operating mechanism of the Elliott, Class C alarm water column, for high and low water, is shown in Fig. 12. As the float rises, the lower button on the stem engages the lower hinged lever to the whistle pipe and forces it upward, thus lifting the valve from its seat, and permitting a small amount of steam to escape which blows the whistle. When the water level falls below the high level point for which the alarm is adjusted, the lever is released and falls back to normal position, and forces the valve to its seat.

In the case of low water, the upper button on the float stem depresses the upper lever, the lower arm of which engages the upper arm of the lower lever, and opens the valve in the same manner as if the lower lever were raised on account of high water. The whistle blows until the water level rises above the low level point for which the alarm is adjusted. By adjusting the buttons on the valve stem, the alarm can be made to sound at any desired water levels, but it is the usual practice for the high alarm to be sounded when the water level reaches the uppermost gage cock on the column; and the low alarm when the water level falls to the lowest gage cock.

Intended to sound the alarm for low water only, the Elliott Class "F" low water alarm column shown in Fig. 13 differs but little in operation. A lever containing a needle valve is hinged to the whistle pipe, and as the buttons are attached to the float stem directly above and below this lever, the valve is held to its seat when water is at or above low level, due to the buoyancy of the submerged float. When the water level falls below the point for which the alarm is adjusted, the float loses its buoyancy, and the lever drops, opening the valve and sounding the alarm.

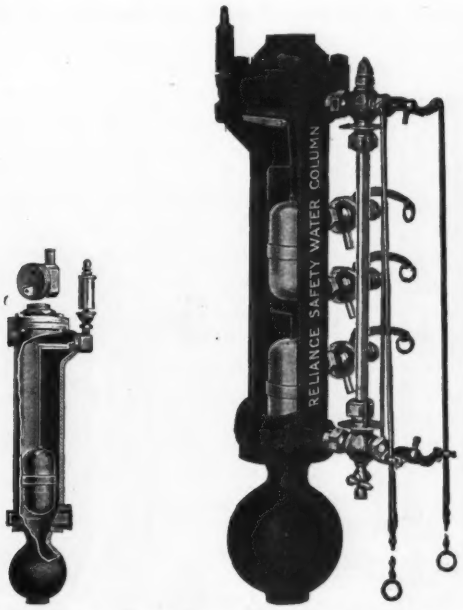


FIG. 14. RELIANCE LOW WATER ALARM COLUMN

FIG. 15. RELIANCE COMBINED HIGH AND LOW WATER ALARM COLUMN

These water columns are manufactured by the Elliott Co., of Pittsburgh, Pa.

Reliance Safety Water Columns

RELIANCE safety water columns, manufactured by the Reliance Gauge Column Co., of Cleveland, O., are of 2 types, one column for combined high and low alarms and the other for low water alarm only. In the low water alarm shown in Fig. 14, a bell-crank lever connects the valve with the float, which by reason of its buoyancy presses upward, keeping the valve closed as long as the water line is above the center of the lower

gage cock. Whenever the water level falls below that point, the float drops and opens the whistle valve.

The low water part of the combined high and low water alarm, is similar to the low water alarm, with the lower float rod bent to pass around the upper float. For the high water alarm, the action is reversed, the bell-crank is turned over and the float hangs upon it until the water rises high enough to lift it and blow the whistle.

The Wright Safety Alarm Water Columns

A round unattached ball float which, upon reaching the adjusted high and low limits of water level, actuates a lever-controlled whistle valve, is the operating medium of the Wright combined high and low alarm shown in Fig. 16. When the level of the water reaches the bottom gage cock, the weight of the ball acts upon a basket which by a rod connection pulls down on the short arm of a lever, opening the valves and blowing the whistle.

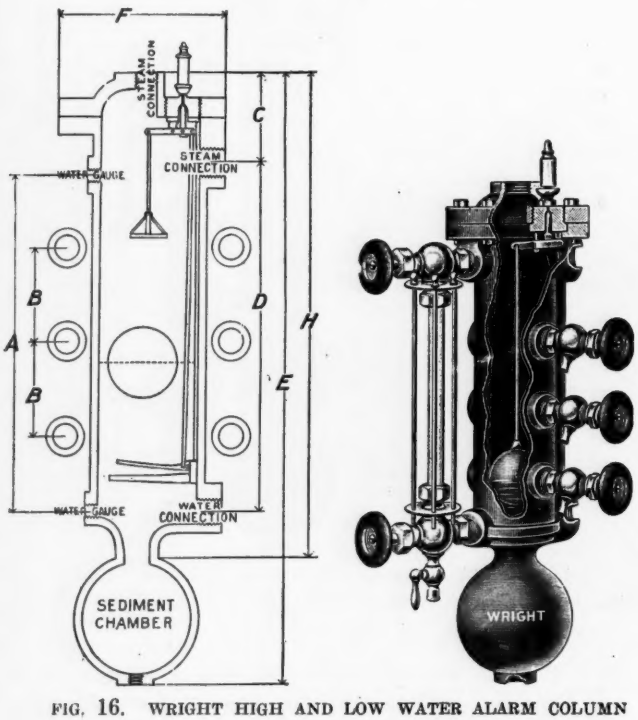


FIG. 16. WRIGHT HIGH AND LOW WATER ALARM COLUMN
FIG. 17. WRIGHT LOW WATER ALARM COLUMN

When the water level reaches the top gage cock, the buoyancy of the ball presses upward on a rod connected to the long arm of the lever, which unseats the valve and allows the whistle to blow.

In the Wright column for low water alarm only, as shown in Fig. 17, the ball is attached directly by a float rod to the lever which actuates the whistle valve. Either type of column may be tested by opening the column blowdown valve, which lets the water out, lowers the float and causes the whistle to blow as if low water actually existed in the boilers. This operation also serves to cleanse the working parts in the column thoroughly.

These water column alarms are made by the Wright Mfg. Co., of Detroit, Mich.

Ashcroft Low Water Alarm

This alarm has an operating principle quite different from that of the other types of alarms. When the water falls to the danger level in the boiler, steam enters the vertical column and melts a fusible disk, thus allowing the steam to blow the alarm whistle. This type of alarm is shown in Fig. 18 attached to a vertical boiler.

The Ashcroft Mfg. Co., of New York City, is the maker of this alarm.

The Vigilant Safety Water Column

This column, shown in Fig. 19, which is manufactured by the Lunkenheimer Co., of Cincinnati, O., is provided with a float, C, attached to the rod, D, which operates through a hole in the valve lever, E. When the water reaches the high limit, the stop, J, which can be placed in any desired position on the rod, strikes the valve lever and lifts L from its seat, allowing steam to

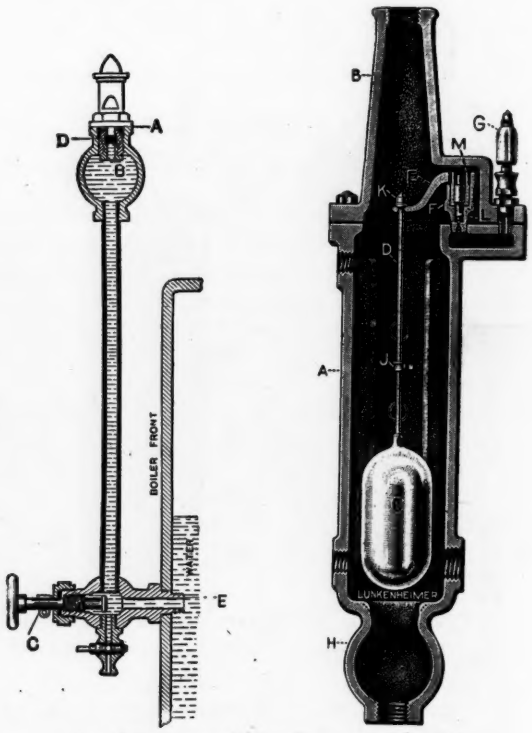


FIG. 18. ASHCROFT LOW WATER ALARM
FIG. 19. THE VIGILANT SAFETY WATER COLUMN

pass through to the whistle. When low water causes the float to drop to the low limit, the knob, K, on the rod, forces the valve lever down, which also opens the valve, allowing the steam to blow the whistle.

It will be observed that the valve lever E, is not directly connected to the valve, L. The valve casing, M, by means of the two lugs on the top, is pivotally connected to the lever, and by this arrangement the valve is caused to travel in an absolutely vertical path.

U. S. Civil Service Commission announces an examination, March 27, for mining engineer, salary $4000; Form 2118.

Economizers

FORMULAS DEVELOPED TO DETERMINE MOST ECONOMICAL OPERATING CONDITIONS.

BY JOHN D. MORGAN

IN THE past few years, power station design has undergone a complete change and among the many changes that have taken place, the one that is most marked is that of the return to the use of economizers in the boiler plant.

Every large plant that has been built during the past 2 yr. has included or made provision for the installation of economizers. This has been a natural development along the line of efficient operation of power plants and has been brought about by the universal use of stokers and motor drive for auxiliaries.

In considering an economizer installation, several factors or conditions must be taken into account, the more important of them being:

Design and installation features.

Temperature of flue gases and water entering economizer.

Temperature rise desired or obtainable.

Decrease of fuel due to economizer installation.

First cost of installation.

Fixed charges on economizer installation.

Net saving resulting from economizer installation.

It is apparent that the first step in any discussion of this nature should be that of ascertaining the formulas and calculations involved or needed in figuring economizer performances. Suppose we let:

D = Mean temperature difference.
X = Rise in temperature of feed water.
T_1 = Temperature of inlet flue gases.
T_2 = Temperature of inlet water.
T_3 = Temperature of outlet flue gases.
T_4 = Temperature of outlet water.
W = Lb. of feed water per b.hp.
G = Lb. of flue gas per lb. of combustible.
c = Lb. of coal per b.hp.
Y = Sq. ft. of economizer heating surface per b.hp.
S = Specific heat of gases.
U = B.t.u. absorbed per hour per sq. ft. per degree difference in temperature.
WX = B.t.u. absorbed by feed water per b.hp.
GcS = B.t.u. given up to feed water for each degree reduction in temperature.
UDY = Heat absorbed per b.hp.
H = B.t.u. per lb. of steam.
C = Amount of B.t.u. purchased for 1 cent.
E = Eff. of boiler and furnace.
P = Cost of power for induced draft fan per b.hp. developed.
FC = Fixed changes per b.hp. developed.

then $$WX = UDY = \frac{UY \times GcS \times \left(T_1 - T_2 - \frac{X}{2}\right)}{2UY + GcS}$$

$$Y = \frac{X\left(\frac{W}{U} + \frac{W+GcS}{2GcS}\right)}{T_1 - T_2}$$

$$X = \frac{Y(T_1 - T_2)}{\frac{W}{U} + \frac{W+GcS}{2GcS}}$$

$$D = T_1 - T_2 - \frac{X+WX}{\frac{GcS}{2}} \text{ or } \frac{(T_1 - T_4) + (T_3 - T_2)}{2}$$

$$GcS = \frac{\frac{W}{U} + W}{2(T_1 - T_2)\frac{Y}{X} - 1}$$

With the preceding formulas, it is possible to compute all practical operating problems.

In order to secure efficient economizer operation, it is first of all necessary to determine whether the proper design and installation features have been obtained.

It has become an undisputed fact that a large boiler of 1000 hp. capacity or greater should have its individual economizer and draft equipment. The ideal installation consists of a forced draft equipment underneath the furnace grates and an induced draft system on the economizer outlet. This is by far the most flexible draft system obtainable. The induced draft fan should be run at a constant speed, the force of draft regulated by damper control. In every installation a bypass flue should be built. At all times it is desirable to maintain a constant or rather uniform gas velocity through the economizer. Great care should be exercised in the design of the economizer walls in order that a proper heat insulating wall may be obtained with a total absence of air leaks. The water flow through the economizer is of vital importance and for a general rule it will be found advisable to have the water flow up and down as many times as possible or, in other words, until the pressure drop through the economizer reaches 30 lb. as a maximum. Care should be exercised to see that a proper soot-cleaning apparatus is installed and also that a properly designed soot hopper and ejector has been provided for the removal of the soot. There are other small construction and design features which if properly attended to will aid the efficient operation of the economizer unit.

The temperature of water entering the economizer should never be lower than 80 deg. F. on account of the possibility of moisture collecting on the tubes. The best operating inlet temperature is between 100 and 150 deg. F. The minimum flue gas inlet temperature should be 450 deg. F.

The temperature rise is a variable and only by taking into consideration the several factors noted in the foregoing formula can it be calculated.

The decrease in fuel cost to an economizer installation can be obtained from the following formula.

$$\frac{100\,WH\,(T_4 - T_2)}{CE\,(H + 32 - T_2)} = \text{cents saved per b.hp. developed.}$$

The first cost of an economizer installation depends largely on the design factors, but in most cases a con-

servative figure is about $1.05 per sq. ft. of heating surface. This includes price of forced draft fan and installation charges.

A curve is given in the Practical Reference Tables which shows the cost per b.hp. for various amounts of heating surface per b.hp.

Economizer fixed charges are figured in the same manner as other fixed charges. As a general rule, the fixed charges will amount to 12½ per cent of the installation cost, the average life being about 20 yr.

The net saving due to an economizer installation can be found by the following formula:

$$\frac{100\,WH\,(T_4 - T_2)}{CE\,(H + 32 - T_2)} - P - FC = \text{net saving in cents per b.hp. developed.}$$

A series of curves is given in the Practical Reference Tables of this issue showing the various factors which affect economizer operation. These curves are based on the results obtained from a 7750-sq. ft. economizer working on a connected b.hp. of from 1275 to 4100.

Coal and Ashes Handling and Storage--III

JUDICIOUS USE OF FLIGHT CONVEYORS MAY REDUCE SPACE AND AVOID HEAVY RAILROAD TRESTLES. BY HENRY J. EDSALL

IN THE BOILER ROOM for the Hooker Electrochemical Co., Niagara Falls, N. Y., Fig. 5, the coal will be elevated by a continuous bucket elevator, and distributed by a reversible flight conveyor over the coal bin, underneath which is a 1-ton motor-propelled weighing hopper. The ashes will be handled in a car running on the basement floor, receiving the ashes from the hoppers under the stokers and delivering them to a skip hoist which dumps them into the elevated ashes bin at one end of the building.

The track hopper is 12 ft. square and constructed of ¼-in. steel. Underneath this track hopper is an apron feeder 30 in. wide by 8 ft. centers, delivering to a 28 by 36-in. two-roll coal crusher, from which the coal goes into the continuous bucket elevator 74 ft. centers, constructed with a double strand of 18-in. pitch, steel-strap, steel roller chain, with buckets 17⅝ in. deep by 8 in. projection and 16 in. long continuously attached thereto. This elevator delivers to a reversible flight conveyor with 8 by 19-in. roller flights attached at 2-ft. intervals to a single strand of No. 730 malleable iron chain. The coal handling machinery has a capacity of 75 tons per hour.

Ashes cars, which are standard 40 cu. ft. side-dump, deliver to 45-cu. ft. skip which has a vertical lift of 83 ft. The ashes can be delivered either to railroad

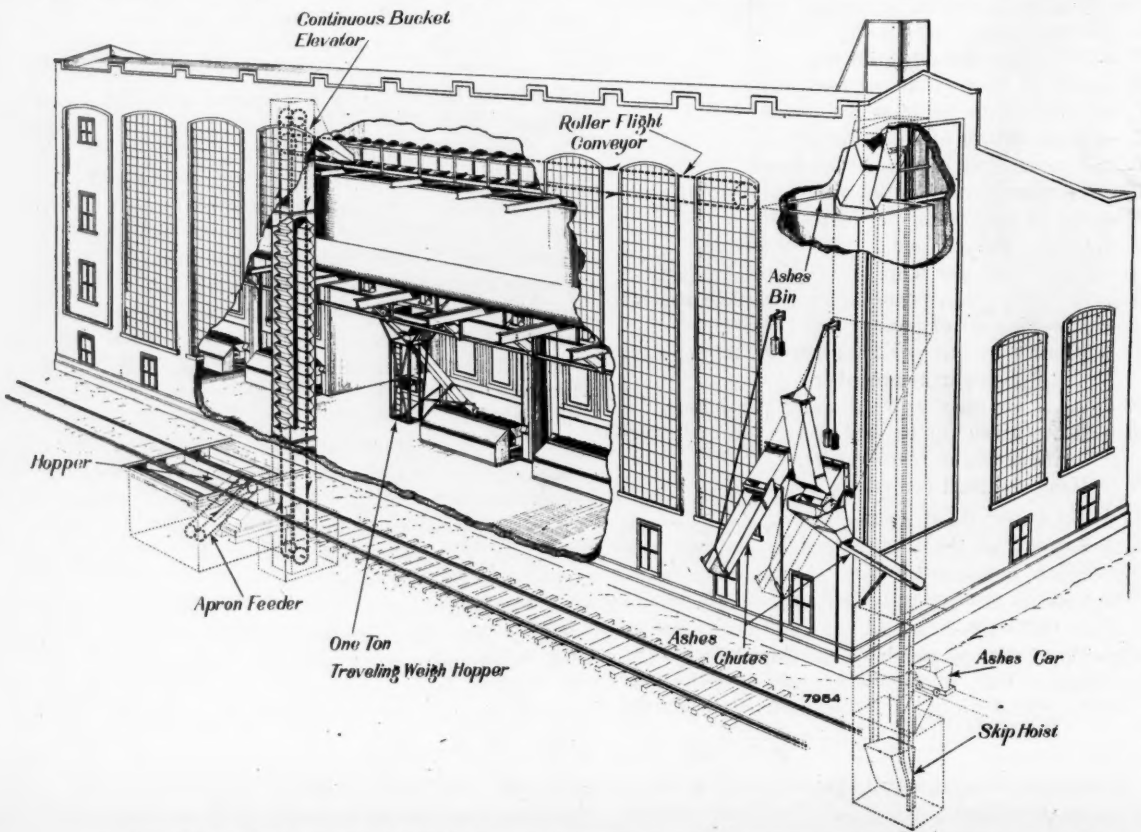


FIG. 5. CONTINUOUS BUCKET ELEVATOR WITH REVERSIBLE FLIGHT CONVEYOR AND SKIP HOIST FOR ASHES

cars, or by means of additional chute to wagons.

Motors used are 20-hp. motor for the coal crusher and feeder, 10-hp. motor for the coal elevator, 15-hp. motor for the flight conveyor and a 15-hp. motor for the skip hoist.

Flight Conveyors vs. Trestles

Sometimes a single conveyor of the belt conveyor or flight conveyor type is used for taking the coal up an incline and then horizontally over the coal bin in the boiler room. A plant using a belt conveyor in this way is shown in Fig. 6.

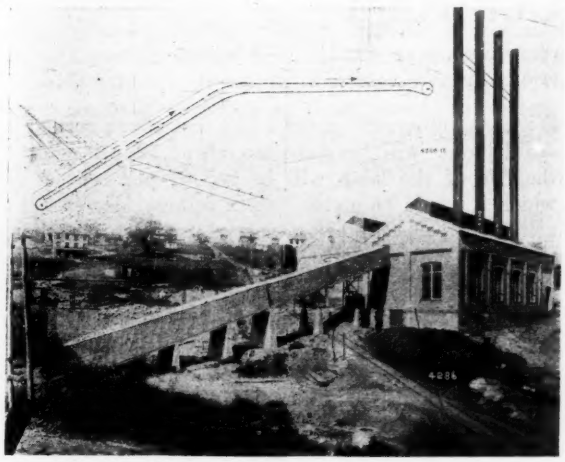


FIG. 6. FLIGHT CONVEYOR, FOR RAISING AND DISTRIBUTING WITHOUT CRUSHING

In many cases, probably in most cases, where railroad trestles are built for storing coal, a better and less expensive arrangement could be obtained by having the railroad track on the ground level and using conveyors to elevate it and distribute the coal, and where an overhead supply is desired the conveyors can usually be arranged to transfer the reserve coal to the overhead bins. A case where the design was changed from a railroad trestle to a conveyor arrangement is shown in Fig. 7.

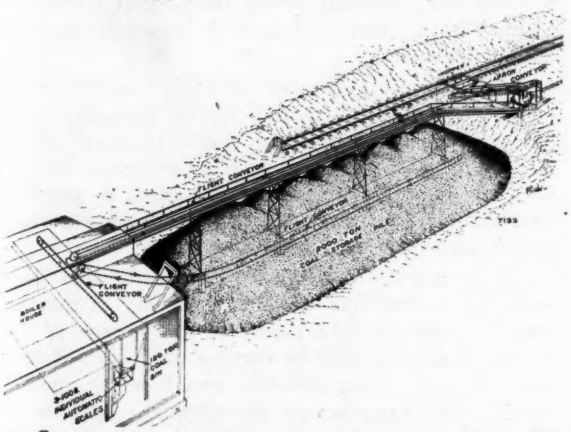


FIG. 7. FLIGHT CONVEYORS FOR DISTRIBUTING TO BOILER HOUSE AND STORAGE AND FOR RECLAIMING FROM RESERVE

Railroad track comes in at a level considerably above the boiler room floor and the coal storage area, and it was the intention to continue the railroad track out on a trestle so that the coal could be dropped underneath for the reserve storage and delivered to a conveyor arrangement which would deposit it in the boiler room bin for the supply to the mechanical stokers. It was found, however, on further investigation that the conveyor arrangement illustrated would be cheaper in first cost, would handle the coal with less labor cost, and the amount of storage was also largely increased over that which could be conveniently obtained with the trestle. A crusher is provided, supplied from the track hopper by an apron feeder, and discharging to the distributing conveyor, which, taking coal along the light trestle, delivers it to the ground storage or takes it directly into the boiler room and delivers to a cross-conveyor over the overhead bin.

Underneath the coal pile is a concrete tunnel with a reclaiming conveyor to which the reserve coal can be fed and taken to the conveyor over the boiler room. Delivery from the overhead bin to each of the three mechanical stokers includes a 100-lb. Richardson automatic scale which will automatically weigh all the coal which is delivered to each boiler. The capacity of the overhead bin in the boiler room is about 120 tons, while about 300 tons can be stored in the outside reserve storage. The daily coal consumption of the plant is about 65 tons.

U. S. Civil Service Commission announces an examination for junior engineer, on March 21 and 22. Vacancies occurring in the Water Resources Branch of the Geological Survey will be filled from this examination. Entrance salaries will range from $1080 to $1200 a year and expenses when on field duty. Appointees from this examination will be eligible for promotion to the grades of assistant engineer and full engineer after they have demonstrated their fitness for such promotion to the satisfaction of the Department and the Commission. The salaries of assistant engineers range from $1380 to $2000 a year, and for engineer from $2400 to $3000 a year. The applicant must show that he has graduated in engineering from a college or technical school of recognized standing, or that he is a senior student in such an institution and expects to graduate within 6 mo. from the date of this examination. Applicants must have reached their twentieth but not their thirtieth birthday on the date of the examination. Apply for Form 1312.

Foreign trade opportunities are given in the Commerce Reports of the Bureau of Foreign and Domestic Commerce as follows: In Switzerland, No. 23,769, there is a market for laminated and drawn electrolytic copper wire, insulating paper for copper conduits, oils for the manufacture of insulating material, and iron bands for exterior armoring of electric cables. In Spain, agency is desired for the sale of motor and electric appliances, No. 23,772. Full information can be had by writing to the Bureau at Washington, D. C., mentioning the numbers as given.

Electrical Machinery and Appliances

For Generating, Transmitting and Using Current

Generator Control--I

METHODS AND APPARATUS EMPLOYED IN THE MANUAL REGULATION OF VOLTAGE

ELECTRICITY, like air, water, steam, etc., is of service to man only when under proper control. The flow of electric current in circuits supplied by so-called constant-potential generators is dependent upon the resistance of the circuit and the requirements of the consuming devices, and is limited only by the capacity of the generators, although circuit-breaking devices should be provided to prevent damage to the machine due to possible overloads. Except within specified limits dependent upon service requirements, generator terminal voltage must vary but little and as each variation in prime-mover speed, machine load and winding temperature results in a proportional variation in terminal voltage, it is imperative that some form of control be employed.

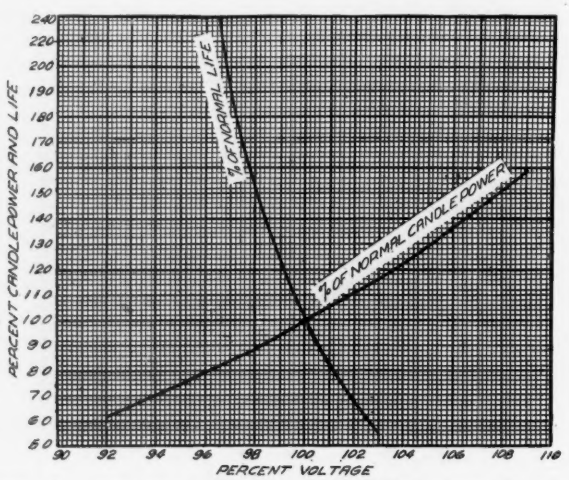


FIG. 1. RELATION BETWEEN OPERATING VOLTAGE AND RESULTANT LIFE AND CANDLEPOWER OF INCANDESCENT LAMPS

Maintenance of proper voltage is of vital importance to the life of incandescent lamps. Operating them above rated voltage will, of course, increase the candlepower and decrease the watts consumption per candlepower, a fact which may at first thought appear advantageous. This, however, is not always the case, as may be seen by referring to the curves in Fig. 1, showing the relation between the life and candlepower of incandescent lamps operating under different percentages of rated voltage. With the voltage increased 2 per cent above normal, the candlepower will be increased about 12 per cent, but the life of the lamp will be but 65 per cent of that which it would be under proper voltage; decreasing the voltage 2 per cent below normal increases the life of the lamp 50 per cent, and decreases the candlepower 11 per cent.

Referring to the fundamental equation of the direct-current dynamo, we find the generated voltage to be directly proportional to the number of field magnet poles, the density of the magnetic flux, the number of outside armature conductors and the speed of the armature. The first and third of these factors are fixed and as the speed variation under normal conditions of operation is negligible, it is at once apparent that the terminal voltage may be most readily controlled by means of varying the density of the magnetic flux. And as this in turn is dependent upon the degree of field excitation, any means by which the current flow in the field windings may be controlled will also act as a control of the machine voltage. Inserting some form of variable resistance in the circuit supplying current to the field winding will, therefore, allow the desired result to be realized. Any such resistance is generally known as the field rheostat.

Characteristic generator curves indicate the degree of variation of terminal voltage with increasing output and the necessity of employing a field rheostat. Even in the case of the flat compound-wound generator, which by its very design is supposed to maintain a practically constant terminal voltage, the use of the rheostat in the shunt-field circuit is indispensable.

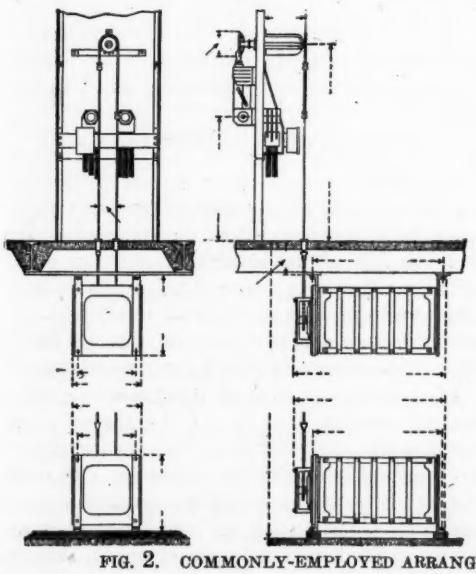
Reviewing the development of the dynamo electric machine, we find that while the majority of these generators employed field rheostats, the voltage of many of them was controlled by varying the length of the air gap; the underlying principle was, however, the same, namely, the variation of the effective magnetic flux. These rheostats which were employed, exemplified by the ones used in connection with the Thomson-Houston system, consisted of a nest of asbestos tubes encased in a well-ventilated iron box and having closely wound upon them German-silver resistance wire. The taps along the circuit of this resistance were connected to a set of contacts arranged in the form of a circle on the marble or slate face plate of the containing case. The desired

resistance was cut in or out in the same manner as is done in present-day manually-operated rheostats by means of a hand wheel attached to a contact arm connecting the resistance to one side of the supply circuit.

Except in the smaller sizes and those employed for special purposes this form of rheostat is no longer used, the heavier current now required to excite the large modern generator and greater degree of safety and reliability demanded on the part of operators having called for somewhat different designs. For moderate-size machines up to about 1500 kw., plate rheostats are generally employed. These consist of plates composed of a base of insulating material to which is attached the resistance wire or ribbon, contacts and lever, the whole being carried by a japanned iron case; in others the resistance material is attached to a plate of porcelain-covered cast iron by means of a coating of fused enamel or cement. Any number of these units may be bolted together and electrically connected in multiple to meet specific requirements.

Field rheostats used in conjunction with large generators are usually of the box type, having resistance in the form of cast-iron grids joined and supported by insulated rods and encased in a framework made up of angle irons and covered by screening. As in the other types, various steps of this resistance are connected to a set of contacts on a marble or slate face plate, which also carries the movable contact arm. In the larger sizes the plate carrying the contacts and contact lever is mounted on pipe or structural supports the same as any switchboard panel.

Direct-current machines are usually provided with field rheostats having a total resistance about equal to that of the winding of the field to be regulated, thus giving a variation of field strength from maximum to ½ maximum with a constant exciting voltage. The resistance of an alternating-current generator field rheostat is usually about twice that of the field winding, giving a variation in field current flow from maximum to ⅓ maximum, at constant voltage.



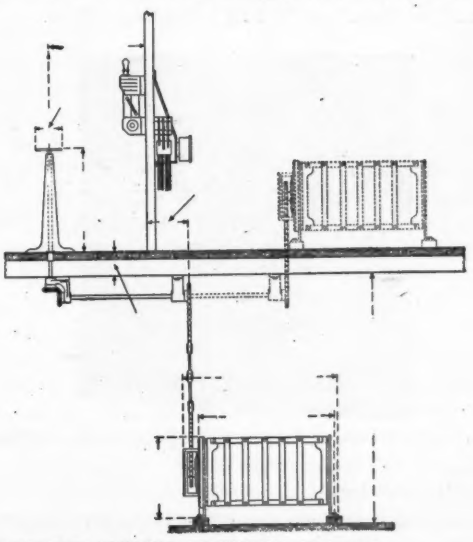


FIG. 2. COMMONLY-EMPLOYED ARRANGEMENTS FOR REMOTE MANUAL RHEOSTAT CONTROL

Control of Rheostats

Size of the rheostat, location of the switchboard and the mass of other equipment frequently mounted on the rear of the panels may require placing the rheostat in some remote location. This may necessitate remote electrical control, although if within close proximity to the switchboard a sprocket-and-chain arrangement with the hand wheel mounted on the face of a panel may be employed; if conditions do not permit otherwise, the rheostat may be controlled by a hand wheel mounted on a pedestal and a series of shafts and gears in addition to the chains and sprockets. Various methods of remote manual control are illustrated in Fig. 2.

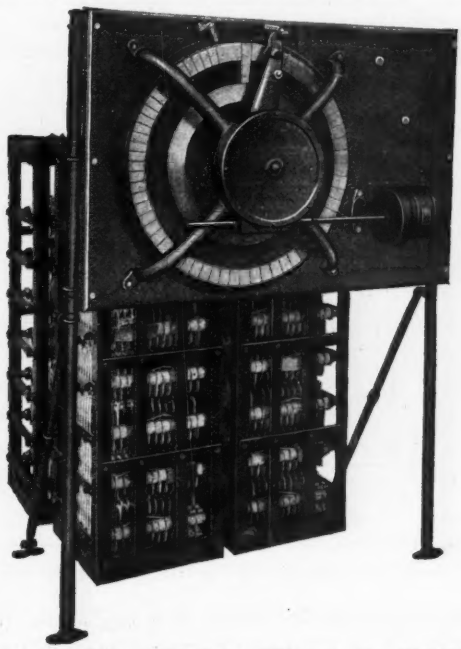


FIG. 3. CAST-GRID RHEOSTAT OPERATED BY ELECTRICAL MOTOR

Electrically-operated rheostats are of the motor or solenoid type. The former, especially adapted for use in connection with field circuits carrying 300 amp. and more, is shown in Fig. 3. Attached to the contact arm is a gear which meshes with a worm near the end of the extended motor shaft. This motor is series wound and reversible, enabling the contact arm to be operated

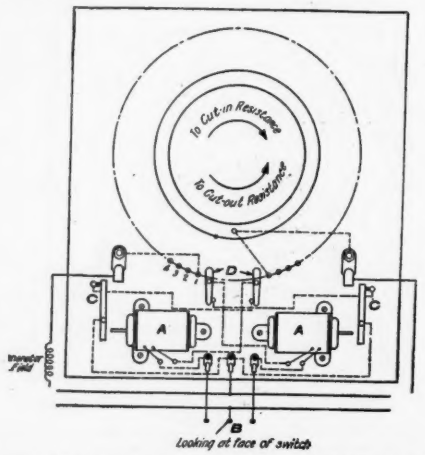


FIG. 4. DIAGRAM OF CONNECTIONS, GENERAL ELECTRIC SOLENOID-OPERATED RATCHET-DRIVEN RHEOSTAT

in either direction by means of a single-pole, double-throw switch mounted on the control panel of the main switchboard. Limit switches operated by the contact arm automatically open the current-supply circuit to prevent over-travel.

Figure 4 illustrates the diagram of connections of a General Electric solenoid-operated ratchet-driven field rheostat, designed to carry currents of from 25 to 300 amp. and voltages up to and including 600 v.

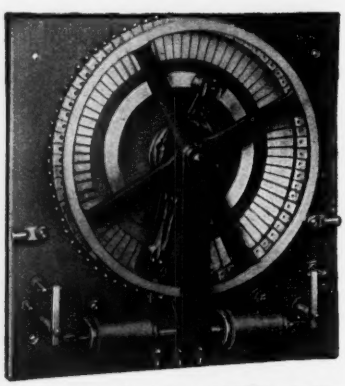


FIG. 5. SOLENOID-OPERATED RATCHET-DRIVEN RHEOSTAT

Rigidly attached to the contact arm is a wheel, Fig. 5, provided with a knurled rim engaged by pawls which in turn are controlled by a core actuated in common by solenoids AA, Fig. 4. With no current flowing through either solenoid winding, the pawls are disengaged and in their normal condition rest midway between the solenoids.

To cut resistance out of the field circuit, right-hand solenoid A is energized and engages the right-hand pawl, which, through the medium of the ratchet wheel, moves the contact arm in a counter clockwise direction until the solenoid core has reached its extreme point of travel. The solenoid winding is then automatically opened by means of small switch C and the pawl immediately drawn to its neutral position by a spring, automatically closing the circuit of the solenoid switch by small switch C. This cycle is repeated as long as switch B is kept closed to the right.

To cut resistance into the field circuit, switch B is thrown to the left when the same action takes place by left-hand solenoid A and switch C resulting in the contact arm moving in a clockwise direction.

Similar to the scheme employed in connection with the motor-operated field rheostat, each end of the switch dial is provided with a limit switch, D, automatically operated by the contact arm, thereby opening the solenoid circuit when the resistance is entirely cut in or out. This protects the apparatus in case the controlling circuit is left closed until the contact arm has reached its extreme point of travel in either direction.

Advantages of this type of switch as compared with

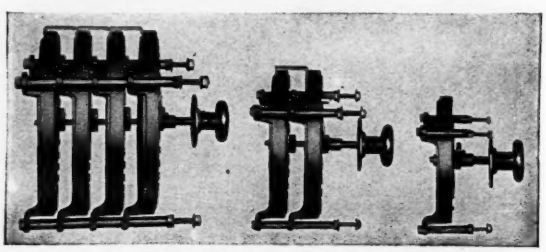


FIG. 6. FOUR-, TWO- AND SINGLE-UNIT PLATE RHEOSTATS FOR DIRECT MANUAL CONTROL

those operated by motor are: Lower cost; closer regulation; less space required; lighter construction; compactness; parts more readily duplicated, and less attention required.

Selection, Installation and Care

Three essential points to be considered in selecting a rheostat are its durability of construction to withstand the service demanded of it; low heating limits to prolong the life of the insulation and reduce the fire hazard to a minimum; and ability to handle the necessary range of variation in the field resistance. Another important factor is a sufficient number of contacts or divisions of resistance to give proper regulation of voltage. Each additional step of resistance inserted should change the current capacity of the rheostat an equal amount and any such change in amperes per step is equal to the quotient obtained by dividing (the difference between the current flow with the rheostat short-circuited and the current flow when all resistance is in circuit), by the total number of steps or contacts. The current flow when n steps or contacts are in circuit is equal to the current flow when the rheostat is short-circuited minus the product of n times the change in amperes per step.

The radiating surface on either side of any plate-type field rheostat expressed in square inches, should be about 1/5 the product of (the current flow with rheostat

short-circuited, times current flow with all resistance in circuit, times the total resistance of the rheostat). The current flow values are, of course, expressed in amperes while the resistance is in ohms, the value of which may readily be obtained from the name plate of the rheostat.

Due to the very nature of their function, rheostats are a source of heating and should, therefore, be installed sufficiently removed from all cases tending to interfere with an ample circulation of air through the elements. When necessary to place the rheostat near a wooden wall or any inflammable structure or material, some form of barrier such as a piece of ¼-in. asbestos board should be interposed, as a preventive measure.

As in the case of all other electrical machinery, cleanliness is of vital importance. When the resistance elements are of the wire- or ribbon-coil or cast-grid type, these should be blown out at frequent intervals and in order to eliminate flashovers and arcing, all contacts should be kept clean and bright and any accumulations of dirt between the contacts removed. Keeping the bearings well lubricated with a high-grade machine oil will prevent deterioration and interference with the free action of the moving parts.

Why Didn't the Generator Generate?

By N. N. Bava-Adam

BEFORE describing the following incident, I should say that I do not know much about electricity. My knowledge of this consists of running, properly and efficiently, generators for electric lighting and small motors, together with that of proper wiring for such. In short, I can put up and work a new lighting installation from the foundation of the generator to the complete wiring and switch gear without any outside help.

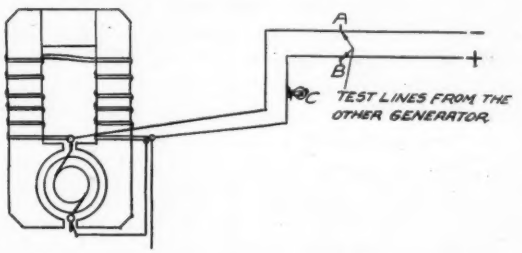
Now, coming to the subject, there are two separate direct-current compound-wound generators for the electric lighting of our spinning mills, one of 110 v. and 60 amp. and the other of 110 v. and 120 amp. Both are driven by separate steam engines, through a belt drive, in separate buildings, and have no connection with each other.

On Saturday evening, while starting the smaller unit, it refused to generate; neither did the pointer of the voltmeter give any trace of current, nor did the pilot lamp show any sign of getting current, although it had worked properly in the morning. I tried everything I could think of to find the fault, such as examining the connections at terminals on the machine, at the switchboard, every connection and screw that was likely to get loose and break the circuit, also the main fuse. There was, however, no sign of any current being generated. As it was a long day, we required lights in the mills for half an hour only before stopping for the day, and that half hour passed in trying in vain to find the fault. As the next day was Sunday, I postponed the job for that morning.

I then disconnected all the main wiring from the generator to the main switchboard, polished every brass screw and fitting, varnished the armature, trimmed the brushes (which were of copper) and cleaned the commutator. After reconnecting and fixing all the wiring and fittings, the generator was started, but with the same result.

For the time being I was quite confounded and could not make out what to do. It then, however, occurred to me to test the series and shunt field coil windings to see whether there was anything wrong with them. As I had no galvanometer or any such instrument, I made the following arrangement to test the circuits of the field wiring: The terminals of the series and shunt windings were disconnected from the mains and brushes, and after bringing down a line from the other generator, with an incandescent lamp fitted in the circuit, as shown at C, I joined the terminals of lines A B to those of the shunt winding of the faulty generator, and putting the switch on, the lamp was lighted, which proved that the shunt winding was without fault. In the same way, the series winding was also tested and found to be all right.

After testing both windings and thinking the matter over again for a while, it occurred to me to keep the generator running while the current was on in the field coils, so as to excite the magnet; running in this way for a few minutes, I disconnected the wiring of the test



CONNECTIONS SHOWING METHOD USED TO RESTORE RESIDUAL MAGNETISM

lines A B and put the brushes and terminals as they properly should be. As soon as the brushes were thrown on the commutator the pilot light began to glow and the pointer of the voltmeter moved and showed proper voltage. While all the switches of the branch lines were thrown in, all the lamps were lighted as usual and the difficulty was solved.

In my opinion, the current was not generated, because the magnet must have lost its power, and it required re-exciting; and when the current was passed through the coils, the magnet must have received its required excitation. The generator is running now without trouble, a few hours in the morning and in the evening. Up to now I cannot understand, however, why it so suddenly refused to generate.

If the magnet had lost its energy, and it required re-exciting, why did this occur on that particular day after running for about 18 yr. without any such trouble? I hope that readers of Practical Engineer will discuss the matter and express their views on that point.

Now last, but not least, the question is, to whom should credit be given for solving this trouble? Can I claim the credit for doing this? No, certainly not. Then, to whom does it go? Of course the honor goes to Practical Engineer, because by reading this paper for years, I have learned many things. But one par-

ticular thing which I have learned is that, whenever there is any trouble never despair and give up, but try to solve it with perseverance and patience, with tools at hand. I might have obtained the services of one of the best electricians, because our factory is near the biggest industrial city in the country; but, being one of the readers of Practical Engineer, I was proud enough not to send for such a man to help me.

The Joy of Living

By Castalia

I SUPPOSE it is the thrills that we power house engineers get occasionally that break the monotony and make our calling interesting. I was employed at one time in a central station of moderate size near the rugged coast line of old New England.

We were furnishing juice to several towns, with a motor load at day and a lighting load at night. Situated as we were on the banks of a creek 3 mi. from the open bay, we had to catch and hold our condensing water, renewing it twice a day at each rise of the tide. The pond holding our condensing water was not as large as it should have been and consequently the water got pretty warm, the injection at times during the summer going as high as 100 deg. This of course meant a low vacuum, about 26 in., low for a turbine. We used a 1000-kw. Curtis 2-stage machine most of the time. The low vacuum caused a rise in pressure between the stages, and the steam being admitted in a series of puffs, caused the atmospheric valve to jump on its seat, and as the load built up when there was about 900 kw. on the machine it was exhausting steam in all directions.

There was a 3-in. relief valve set at 8 lb. piped from the side of No. 1 stage, this was for protection, as the atmospheric valve had given us trouble and we were afraid it might stick on its seat.

When the pressure would build up beyond what the relief valve was set at, this, of course, would blow, the atmospheric line would be exhausting steam, and we would still be running condensing.

An old shoe factory engineer wandered in one afternoon; I guess he had been a marine man in his earlier days. He looked at the vacuum gage, which recorded 26 in.; he looked at the 3-in. relief line, which was blowing a steady stream; at the 12-in. atmospheric line, spitting out enough steam to heat the Flat Iron Building.

Said he: "I have followed this work for 40 yr. as man and boy and damn me this is the first time I ever saw a steam engine exhausting in the 3 directions at the same time."

The powers that be, after many consultations, finally decided that we needed a new atmospheric valve, one that we could weight down.

The valve was purchased and duly installed, and it fell to my lot to demonstrate the staying qualities of said valve. It had a long lever attachment with a hook rod on the end and weights were suspended on the hook rod to keep the valve from lifting. I received orders to weight the valve down during the Saturday night load and keep the steam from exhausting through that valve if possible.

As the load came on, I had about the normal rating of the turbine, 1000 kw., and the condensing water being fairly cool, the mercury column registered 27.3 in. Every impulse of the steam would cause the atmospheric valve to jump on its seat, and this caused the weights hooked to the long lever to start swinging. The exhaust line was in the basement running nearly the whole length between two other pipes that were not covered, and when the weights started swinging they beat a tattoo alternately on these pipes. Now, keep in mind the watch engineer was also switchboard operator and oiler, the only help being two men in the fire room.

When the music started, I hustled for the basement; but when I got there, I could find nothing at hand to check the side swing of the weights, so I returned to the engine room looking for a couple of pieces of board about 6 ft. long, not being quite sure in my own mind what I was going to do with them when I found them.

I went to the engine room door that opens in the back yard when—crash! bang! A volley of steam shot heavenward from the end of the atmospheric pipe. I ran back to the turbine, which was staggering like a drunken man looking for a soft place to lie down. The frequency meter on the switchboard showed 55 cycles and still going back.

I had to do something and do it quick; I pulled off the street lights, but the old machine was groggy still.

Now I was up against it. I had to pull out one of the 5 towns that we were supplying, but which one should it be.

It meant hell to pay no matter which line was cut off. I ran over in my mind which line had had the least trouble in the past.

I decided to pull H. and G.; they had had unbroken service for over a year. I had to make this decision quickly for the old Curtis was rapidly going to sleep.

I pulled the circuit breaker. The frequency meter stopped in its downward career, hesitated, and started to climb back. I now had the old machine back on her feet, but I had dumped 20 per cent of my load overboard. I now had to salvage what I had lost and do it quick.

I had kept a 500-kw. set warmed up with the condenser running; I brought her to the front and cut her on the line, a little quicker, I am thinking, than the ethics of the game allow.

I built load on the 500-kw. set until the steam pressure leaving the first stage of the Curtis turbine had dropped enough to allow the atmospheric valve to close. I dropped in the H. and G. circuit breaker and put on the street lights.

Ye gods, my troubles had only begun! The recording steam gage was showing a drop of 15 lb. and still going.

I hustled for the boiler room. The firemen were doing their best, and the Taylor stokers were working over time, but all to no purpose; the steam kept sliding down hill.

I cajoled and coaxed and threatened; first the firemen and then the boilers; but the steam pressure still receded.

I went back to the engine room and again pulled the street lights off, hoping this would be enough, but my

hopes were in vain. More load would have to be dumped. I again pulled the H. & G. circuit breaker and then waited for results.

I hovered around the recording steam gage as a hawk might hover over a chicken coop, and my feelings were a good deal the same as a man's in the dentist's chair, waiting for the oral surgeon to get his instruments ready.

Lord bless us, but how the telephone did ring.

I was called everything from a gentleman to a jackass, and given to understand I was anything but a power house engineer.

However I had the satisfaction to see the steam come back to the 150-lb. mark, and in a few minutes I had the circuit breaker in and the street lights on.

I went over my rounds to make sure everything was all right, and believing I hav earned the right to take a long breath I filled the old corn cob pipe and put my feet on the table.

On entering the basement after I had got things straightened out I found that the side swing of the weights had twisted the long lever of the valve from its fulcrum; this released the valve and the steam after doing its work in No. 1 stage passed into the atmosphere, No. 2 stage not doing any work at all, and consequently the machine gave up the ghost.

Intercooler Efficiencies

ADVANTAGES GAINED BY THE USE OF INTERCOOLERS; REASONABLE EXPECTATIONS FROM INTERCOOLERS; EFFECTS OF MOISTURE ON EFFICIENCY

TWO-STAGE air compression for the working pressures most commonly used, say 6 to 8 atmospheres, absolute, may be said to be now practically universal, at least where new compressors are installed, and even for pressures as low as 4 atmospheres 2-stage compression is well warranted and quite frequently employed. The practice has not only strong theoretical backing, but also the endorsement of practical experience.

Various advantages may be cited for the arrangement: an actual reduction of power output per unit of air delivered, a more equitable distribution of load per revolution or cycle of operation, prevention of high temperatures for the working surfaces, and consequently better lubrication, the elimination of moisture and the delivery of the air in better condition both for transmission and for ultimate use.

The employment of 2-stage compression is entirely for the sake of the cooling of the air and the consequent reduction of volume which may be effected between the stages, and therefore the entire responsibility for the economy and practical success of 2-stage compression rests with the intercooler. Since the general adoption of 2-stage compression, under the stimulus of competitive manufacture, and the constant aim to attain to approximately perfect efficiency, the intercoolers have been successively improved until at present there is little more to look for in that direction.

With perfect intercooling the temperature of the air entering the high-pressure cylinder should be no higher than the intake temperature of the low-pressure cylinder, but this is not attainable. Efficient intercooling is considered to be attained when the air is cooled to within 20 deg. F. of the entering cold water temperature. Compressor builders can show actual intercooler temperature reduction to within 17½ deg. of that of the cooling water with a flow of 2½ gal. per minute per cu. ft. of free air, and to 14½ deg. with 4 gal. of water per minute.

The intake air temperature and the temperature of available cooling water with the resulting compression efficiency or economy, must vary greatly with the seasons. In the winter months when temperature is low and the air is dense a compressor will deliver more air with less power input than in the hot summer months. The following are quite within the possibilities of working air temperatures in the ordinary range of the seasons:

Air Intake Temperature	Temperature of Air Entering Intercooler
70 deg. F.	254 deg. F.
32 deg. F.	175 deg. F.
0 deg. F.	145 deg. F.

The intercooler air pressure of course will not vary, as this is determined by the relative capacities of the low pressure and the high pressure cylinders, regardless of its discharge pressure.

Now, it is readily seen that an intercooler could not possibly satisfy the theoretical requirement of delivering the air to the high pressure cylinder at the same temperature at which it enters the low-pressure cylinder if the free air temperature was 20 deg. and the cooling water temperature 50 deg. Operating under such conditions would impose an overload with power input exceeding normal by about 12 per cent. With air intake at 70 deg. and cooling water at 50 deg. it would be easily possible for a good intercooler to deliver the air to the high-pressure cylinder also at 70 deg., this constituting what might be called perfect intercooling efficiency according to the definition.

WATER JACKETING

PROPER water jacketing of cylinder and heads is an important detail of compressor design, and here also there are possibilities for great differences in efficiency. Hot air is in direct and constant contact with the cylinder heads, and very effective cooling may be accomplished here. It has been found that about 11 per cent of air cooling is effected by cylinder jackets, and that the difference between a deep head jacket with proper circulation and one so shallow and so piped as to be non-effective can show a loss in air capacity of 2 per cent and increase in horsepower of 3 per cent. Some designers have held the idea, which, of course, it is impossible to substantiate, that the heated film of air next to the head in the clearance space, with head not jacketed,

would reduce the actual amount of air lost in the clearance, and in this manner increase the volumetric efficiency.

The Moisture in the Air

It is worth while to consider the question of moisture in the air as affecting power consumption and volumetric efficiency. The moisture carrying capacity of air is dependent upon, and its limits are automatically determined by, its pressure and its temperature, especially the latter. The following figures show the pounds of water vapor in 1000 cu. ft. of air at different temperatures and per cent of saturation:

	25%	50%	75%	100%
100 deg. F.	.705	1.411	2.117	2.823
70 deg. F.	.285	.570	.855	1.140
60 deg. F.	.205	.410	.615	.820
50 deg. F.	.145	.291	.436	.582
32 deg. F.	.075	.150	.226	.301

The United States Weather Bureau records for a period of 15 yr. show humidity as follows:

We table a number of localities to show that 100% humidity seldom occurs:

	Humidity 8 a.m.	Humidity 8 p.m.
New York	76%	71%
Chicago	78	72
Denver	61	39
El Paso	53	26
Helena	66	47
Salt Lake City	59	46
Seattle	86	66
Portland	87	63
San Francisco	87	73
Los Angeles	78	64

For the convenience of the writer, with a specific case in mind, we may here consider the operating conditions for a compressor located at Salt Lake City, Utah.

Assumed average conditions for Salt Lake City locality:

Average humidity.....50 per cent
Elevation .....5000 ft.
Atmospheric pressure .....12.14 lb.
Average temperature.....70 deg. F.

Intercooler pressure, when compressing to 100 lb. gage discharge pressure from high-pressure cylinder, and if load is balanced, will be approximately 26 lb., or a little more than 3 atmospheres at 5000 ft. elevation. When compressed to 2 atmospheres, the humidity of the reduced volume will then become 100 per cent and at 3 atmospheres, 117 per cent. Then 17 per cent of the entrained moisture or water vapor is ready to precipitate if the temperature of the air holding the moisture is sufficiently low. It will not precipitate, on account of its velocity through the intercooler, unless the temperature has been reduced to considerably less than 70 deg. F., and this is plainly impossible with cooling water at 50 deg. F.

The temperature at which condensation or precipitation begins is the dew point or the saturation temperature for the given pressure. Air at atmospheric pressure, 70 deg. F. and 100 per cent humidity, will hold in suspension, in 1000 cu. ft. volume, 1.14 lb. of water vapor, and no precipitation will occur unless the temperature is reduced, or a reduction of volume by increased pressure, causes a percentage of humidity above the point of saturation.

The claim has been made that the moisture can be shocked out of the air during its passage through the intercooler by moving it at high velocity against obstructions provided in the intercooler. Velocity in an intercooler can be considered in two ways only. It must be high enough to get maximum cooling due to the sweeping of the air over the tubes. It must be so low that appreciable drop in intercooler pressure does not occur. Intercoolers are now so designed and built that pressure drop, due to velocity, is kept down to 3½ in. to 4 in. water column, or 0.126 to 0.145 lb. per sq. in.

Contrary to the shock idea, if compressed air just delivered from a compressor, and carrying a load of condensed but not precipitated moisture, made excessive by the reduction of volume, could be kept in an unmoving mass, the moisture would slowly precipitate or fall to the bottom of the receiver as its temperature fell; but, as air is usually given no time to stop, only a small portion of its moisture is deposited in the receiver, and this only when the temperature has been reduced. The balance of the moisture is carried along and gradually deposited in the pipe line.

The moisture present in the air of course displaces a certain portion of the air, so that any given volume of air with all the moisture it can carry represents an actual quantity of air slightly less than the same volume of air in which the humidity was comparatively low. Some enthusiasts have greatly exaggerated this and have asserted, or at least suggested, that a standard modern compressor could be improved to the point of delivering 15 per cent to 30 per cent more air by the removal of the moisture in it. It is true, theoretically at least, that a little more air could be put through the compressor and delivered if the moisture were abstracted from the air before it went into the compressor, but the increase would be only about 1 per cent even when the humidity was as high as 100 per cent. Careful tests have shown that when compressing air at 50 per cent intake humidity, and when the water is cool enough to precipitate 75 per cent of the moisture in the intercooler, there is a loss in volumetric efficiency of about ½ of 1 per cent when correction is made for humidity and temperature.

Supposing a modern 2-stage compressor to be running under average conditions, the only improvement it could be expected to make would be a reduction of horsepower of about 1 per cent for each 10 deg. that the temperature of the air leaving the compressor was lowered.

With a compressor with a 200-hp. load, allowing $25 per hp.-yr., and with new intercooler and separator costing $500, it would take 10 yr. to save enough to pay the cost of it, with no other saving whatever.

For the data and most of the arrangement of this article I am indebted to Jos. B. Mossman, of Salt Lake City, Utah.

A reinforced concrete ship of 3000 tons capacity, driven by Diesel engines, is to be built by a Norwegian concern, according to late reports.

How Power and Heating Costs are Determined

FORM SHEETS EMPLOYED IN A LARGE BUILDING TO RECORD AND DISTRIBUTE EXPENSE ACCORDING TO SERVICE RENDERED

TO APPORTION correctly to each branch of the engineering department its actual share of the operating expense, and to charge fairly the various departments of a large store with the expense incurred for electrical work, plumbing, steam fitting, general repairs and power, and to show the management each month what it is costing to operate the plant requires a carefully developed system of records.

Described herewith is a brief outline of the system developed by the chief engineer, Alfred Johnson, for the engineering department of Mandel Bros.' store in Chicago. This department consists of 35 men, of which 12, an engineer, oiler, fireman and coal passer for each shift, are employed inside the generating plant, and the remainder are divided into sub-departments under the direction of a working foreman and employed in the outside repair and installation service. Equipment for this power plant was installed 12 yr. ago, and cost $167,000 exclusive of elevators.

Consisting of 16 floors and 3 basements, and occupying a plot 300 ft. by 150 ft., the building has a connected load of 900 kw., 78,000 sq. ft. of direct and 18,000 sq. ft. indirect radiation. Three neighboring buildings are also supplied with steam, the Stevens Bros. building receiving annually about 500,000 lb. of low pressure steam for heating, while the Columbus Memorial Building and the Venetian Building receive 18,000,000 and 6,000,000 lb. annually of high pressure steam. Total steam produced during the past year was 276,914,000 lb.

Situated 46 ft. below ground level, the boiler room contains 6 350-hp. McNaul boilers and 2 500-hp. Edge Moor boilers equipped with chain grate stokers which are supplied with fuel from overhead bunkers. Coal is delivered to the plant in cars of the Illinois Tunnel Co., and after weighing is dumped into a receiving hopper beneath the tracks from which it is carried to the bunkers by flight and bucket conveyors. All coal is weighed as fired by recording scales in the coal spouts. Ashes are drawn into a bucket conveyor and delivered to a storage hopper from which they are discharged into empty tunnel cars by a high speed flight conveyor.

Generating equipment consists of 3 400-kw., 1 200-kw. and 1 100-kw. direct current dynamos operated on the 3-wire system, 220 and 110 volts. The daily output averages 12,000 kw.-hr., of which 1000 kw.-hr. is supplied to the Columbus Memorial Building.

Boiler Room Report

F704 9-13-16 500

Boiler No.	COAL REPORT 12 A.—8 A. M. Meter Reading	Lbs. Burned	8 A. — 4 P. Meter Reading	Lbs. Burned	4 P. — 12 A. Meter Reading	Lbs. Burned	TEMPERATURE OF FEED WATER					
1							12 A		8 A		4 P	
2							1		9		5	
3							2		10		6	
4							3		11		7	
5							4		12 P		8	
6							5		1		9	
7							6		2		10	
8							7		3		11	
Total							AVE.		AVE.		AVE.	

Water Meter Reading at (12 Midnight)

M Lbs. Water Evaporated ☲ °F. Ave. Temp.

Lbs. Coal Fired

Lbs. Dry Coal Fired

Lbs. Ash Taken Out

Lbs. Water Evaporated per lb. Coal as Fired

Equivalent Evaporation from and at 212° F. Coal as Fired

Engineer	12 A. — 8 A.
Fireman	12 A. — 8 A.
Coal Passer	12 A. — 8 A.
Engineer	8 A. — 4 P.
Fireman	8 A. — 4 P.
Coal Passer	8 A. — 4 P.
Engineer	4 P. — 12 A.
Fireman	4 P. — 12 A.
Coal Passer	4 P. — 12 A.

FIG. 1. DAILY BOILER ROOM REPORT

Feed water is supplied by a turbine-driven centrifugal pump and 2 duplex pumps, each having a capacity of 200 gal. per minute, and passes through a 4-in. venturi meter. For house service, 1 motor-driven centrifugal pump and 3 duplex pumps are provided. Four single vacuum pumps, 2 duplex brine pumps, 2 duplex fire pumps, 3 steam and 1 motor-driven elevator pumps, 1 steam and 1 motor driven pilot pumps, 2 motor-driven drinking water pumps, and 2 pneumatic blowers for the carrier tube system make up the pumping equipment. Except for laundry service, which is tapped direct from the city mains, all water is under the pressure secured from 2 supply tanks located on the roof, each having a capacity of 20,000 gal. Water used daily averages 250,000 gal.

Refrigeration is produced by a 30-ton Kroeschell CO_2 machine and raw water ice is made in 40 100-lb. cans. Brine at 0 deg. F. is circulated to the refrigerators of 2 large restaurants and the drinking water cooler.

Supplementing 31 hydraulic elevators are 6 escalators running from the second basement to the second floor, which are operated by 10-hp. motors. Ventilating air is circulated by 40 fans, operated by motors varying from 5 to 50 hp.

In devising a system of daily and monthly reports and records, space was provided for all data which are essential in determining complete cost of operation, and sufficient details noted to account for any decided variation from previous costs. Shown in Fig. 1 is the daily boiler room report giving the water and fuel used during each shift, and total quantities for the day. Space is provided on the reverse side for remarks, such as repairs needed or made and coal analysis.

Contained in the engineer's daily report is the number of hours that each boiler, engine, pump and compressor was in service. Twice a year an efficiency test is made on each pump to determine a constant for average operation and as each pump is fitted with a counter, the daily steam consumption is obtained. By showing

F 818

Work Ticket

Job No._____ Date_____ 191__

Time Rec'd_____ Job Started_____

Job Finished_____

Charge Dept._____

Nature of Job_____

List of Material	TAKEN OUT	RET'D	USED	COST
HRS. TIME at $				
TOTAL COST				

Job Done by_____ Authorised by_____

FIG. 2. WORK TICKET FOR OUTSIDE SERVICE

P716 B 5 10-13-250

_____ 19__

Boiler and Engine Room Costs

BOILER ROOM			ENGINE ROOM		
Lbs. Coal Burned @ $ Ton,			.000 Lbs. Steam Charged to Engines @ $ M.		
.000 Gals. of Water @ $0.07 M Gal.,			Cost of Engine Repairs,		
Cost of Furnace Repairs, Material Only,			Cost of Dynamo Compensator and Switchboard Repairs,		
Cost of Boiler Repairs, Material Only,			Cost of Supplies,		
Cost of Hauling Ashes,			Cost of Engine Oil,		
Rent, Insurance,			Cost of Cylinder Oil,		
Interest and Depreciation,			Cost of Waste,		
Time of Engineers,			Rent and Insurance, (Engines, Dynamos, Switchboards, Piping and Compensators,)		
Time of Firemen,			Interest and Depreciation, (Engines, Dynamos, Switchboards, Piping and Compensators,)		
Time Coal Passers,			Time of Engineers,		
Time of Repair Men,			Time of Oilers,		
Time of Laborers,			Time of Steamfitters,		
Time of Electricians,			Time of Electricians,		
Time of Steamfitters,			Time of Repair Men,		
			Time of Laborers,		
Total Cost,			Total Cost,		
ECONOMIC RESULTS			**COSTS PER K. W. HR.**		
Lbs. of Ash Removed,			Lbs. of Steam per K. W. Hr.,		
Per Cent of Ash in Coal,			Cost of Labor (Including Office Exp.) per K. W. Hr.,		
Per Cent Moisture in Coal, (by Test),			Cost of Engine Repairs per K. W. Hr.,		
Lbs. of Water Evaporated,			Cost of Dynamo, Compensator and Switchboard per K. W. Hr.,		
Lbs. of Water Evaporated per lb. Coal as Fired,			Cost of Supplies per K. W. Hr.,		
Equivilent Evaporation From and at 212 Degrees, Coal as Fired,			Rent and Insurance per K. W. Hr.,		
			Interest and Depreciation per K. W. Hr.,		
COSTS PER M LBS. WATER EVAPORATED			Total Cost per K. W. Hr.,		
Coal,					
Water,					
Hauling Ashes,					
Furnace Repairs,					
Boiler Repairs,					
Rent and Insurance,					
Interest and Depreciation,					
Labor, (Including Office Exp.),					
Total Cost per M Lbs.,					

FIG. 3. MONTHLY CALCULATION OF BOILER AND ENGINE ROOM COSTS

the total periods of operation of the compressor and brine pumps, and the difference in the outgoing and returning brine, a simple calculation furnishes the refrigeration output on this daily report. A separate daily report contains the hours run by each fan motor, and upon multiplying by a constant based upon the rheostat point at which it operates, the daily kw.-hr. demand is recorded.

Daily switchboard readings are recorded on another sheet which also gives the kw.-hr. supplied to the Columbus Memorial Building. Another daily report sheet gives the mileage covered by each elevator, notes of any repairs made and supplies wanted, and space is also provided for a report of any accident which may have occurred.

These 5 daily reports are turned into the chief engineer's office where their data are transferred by a clerk to the monthly reports. Data relative to the labor and materials employed on outside work are recorded upon the form shown in Fig. 2, which is made in duplicate, one copy being retained at the engineer's office while the other is forwarded to the department receiving the service. The total cost of time and material is transferred to an expense transfer ticket which is forwarded to the auditing department where the charge is entered.

Operating costs of the engineering department are divided into 4 branches: (1) Boiler and Engine Room; (2) Heating and Ventilation; (3) Refrigeration, Pumps and Blowers; and (4) Elevators.

On the reverse side of the form shown in Fig. 3 is a monthly boiler and engine room report, as shown in Fig. 5, giving the daily quantities of fuel burned, ashes removed, water evaporated, hours service of each boiler and engine, and the switchboard output. These amounts are totaled and then employed in calculating total boiler and engine room costs as shown on the front side of the sheet. Depreciation for boilers, engines and generator equipment is taken at 5 per cent; the value used for pumping equipment is 8.3 per cent. As

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Monthly Heating and Ventilating Report

	No. 1		No. 2		No. 3		No. 4		No. 5		
DATE	Hrs. Run	K. W. Hrs.	Hrs. Run	K. W. Hrs.	Hrs. Run	K. W. Hrs.	Hrs. Run	K. W. Hrs.	Hrs. Run	K. W. Hrs.	Hrs. Run
1											
2											
30											
31											
Total											

K. W. Hrs. @ $ K. W.

Cost Labor Attendance Engineers, $

" " Repairs

" of Oil Grease and Waste

" " Repair Parts

" " Supplies

" " Rent and Insurance

" " Interest and Depreciation

TOTAL COST.

Sq. Ft. Radiation @ $ per Season (Exhaust Steam)

M Lbs. Steam @ $ per M Lbs. (Live Steam)

Time of Steam Fitters

" " Engineers

Interest and Depreciation

Cost of Material and Supplies

FIG. 4. HEATING AND VENTILATING COST REPORT

Monthly Record—Refrigeration, Pumps and Blowers

	REFRIGERATION							House Pump No. 1		House Pump No. 2		House Pump No. 3		House Pump No. 4		Drinking Water Pumps			Pneumatic Blowers			
DATE	Compressor, Hrs. Run		K. W. Hrs.	Brine Pumps, Hrs. Run		M Lbs. Steam	Lbs. of Ice Harvested	Hrs. Run	K. W. Hrs.	Hrs. Run	M Lbs. Steam	Hrs. Run	M Lbs. Steam	Hrs. Run	M. Lbs. Steam	Hrs. Run No. 1	Hrs. Run No. 2	K. W. Hrs.	No. 1		No. 2	
	No. 1	No. 2		No. 1	No. 2														Hrs. Run	K. W. Hrs.	Hrs. Run	K. W. Hrs.
1																						
2																						
30																						
31																						
Total																						

,000 Lbs. Steam @ $ M,

K. W. Hrs. @ $ M. W.,

Time of Engineers,

Time of Oilers,

Time of Electrician,

Cost of Oil, Grease and Waste,

Cost of Gas,

Cost of Supplies,

Cost of Repairs,

Interest and Depreciation,

Rent and Insurance,

TOTAL,

_____ 19__

Monthly Boiler and Engine Room Report

	DATE	COAL			WATER		BOILERS Hours Run								ENGINES Hours Run					SWITCHBOARD Average Ampere Hour Load				SWITCHBOARD K. W. Output			
		Kind	No. Lbs. Burned	No. Lbs. Ash	M Lbs. Evaporated	Average Temp.	1	2	3	4	5	6	7	8	1	2	3	4	5	C. M. Bldg.	C. E. Co.	M. B.	Total	C. M. Bldg.	C. E. Co.	M. B.	Total
1																											
2																											
3																											

FIG. 5. MONTHLY RECORD FOR REFRIGERATION, SERVICE PUMPS AND BLOWERS

obtained in this report, the cost of 1000 lb. of steam and a kw.-hr. serve as a basis of charge in calculating the operating costs of the heating and ventilation, refrigeration and pump, and elevator reports as explained later. Daily kw.-hr. used by each fan motor are totaled on the monthly heating and ventilation report, a section of which is shown in Fig. 4. Data for fan motors numbered from 1 to 14 are given on the front side, data for motors numbered from 15 to 28 are contained on the reverse side, and a duplicate sheet is used for the remaining 12 motors.

At the bottom of the reverse side, as shown on the lower insert, the cost of the exhaust and live steam supplied to the heating system, the time of steam fitters and engineers, cost of materials and supplies, and interest and depreciation are given. The cost of the exhaust steam is calculated by the square feet of radiation times a season rate, and the total cost of live steam for heating is charged at the cost per 1000 lb. as determined on the report of boiler and engine room costs, and the kw.-hr. cost determined on that report is employed in calculating the cost of operating the fan motors. Then the labor costs for the fan motor operation are determined to which are added the costs of oil, grease and waste, repairs, supplies, etc., the aggregate giving the total cost of heating and ventilation for the month.

Monthly Elevator Record

DATE	Escalator No. 1		Escalator No. 2		Escalator No. 3		Escalator No. 4		Escalator No. 5		Escalator No. 6		Elevator Pump No. 1		Elevator Pump No. 2		Elevator Pump No. 3		Elevator Pump No. 4		Pilot Pump No. 1		Pilot Pump No. 2	
	Hrs. Run	KW. Hrs.	Hrs. Run	KW. Hrs.	Hrs. Run	KW. Hrs.	Hrs. Run	KW. Hrs.	Hrs. Run	KW. Hrs.	Hrs. Run	KW. Hrs.	Hrs. Run	Steam Consum.	Hrs. Run	Steam Consum.	Hrs. Run	Steam Consum.	Hrs. Run	KW. Hrs.	Hrs. Run	KW. Hrs.	Hrs. Run	Steam Consum.
1																								
2																								
3																								
4																								
5																								
30																								
31																								
Total,																								
Time of Operators,																								
Time of Engineers,																								
Time of Oilers,																								
Time of Electricians,																								
Time of Elevator Repair Men,																								
Rent and Insurance on Pumping Plant,																								
Interest and Depreciation on Pumping Plant,																								
Total Cost,																								

FIG. 6. COST RECORD FOR ELEVATOR SERVICE

Figure 5 shows the record of the refrigerating apparatus, service pumps and blowers, upon which steam or current used by the compressor, pumps or blowers is totaled and charged at the calculated rate. Elevator pumps are excluded from this record, as they are covered in the elevator record. By adding the time costs of the engineers, oilers and electrician, costs of repairs, supplies, etc., the total operating cost of this branch of the engineering department is obtained.

On the reverse side of the monthly elevator record, shown in Fig. 6, the total daily mileage of each elevator is recorded. Then the cost charges for that current supplied to the escalator and the motor-driven pumps and steam for the steam elevator pumps are charged, and the total costs of elevator pump repairs and supplies, elevator repairs and supplies and oil, grease and waste are recorded. These values plus the time costs of the elevator operators, engineers, oilers, electricians and repair men, rent and insurance, and interest and depreciation, give the total cost of elevator operation.

Job Order System in the Plant

By C. H. W.

I HAVE become acquainted with a plant using a job order system in addition to the regular log, for keeping record of repairs.

Each engineer has in his possession a job order book with blanks in duplicate. When he notices work required he makes a note of it in the form of a job order, one copy going into an index box on the desk in the engine room and the other to the office. The maintenance gang which does most of the repairs uses this desk index to keep posted as to work to be done. All considered important is marked "urgent" at the desk. When it becomes necessary to lay up a piece of machinery in order to work on it the engineer is, of course, consulted before the machine is stopped or disabled. Breakdowns are attended to without an order, although one is made out after the work is completed.

Each order is endorsed by the person issuing it, and the chief of the watch initials it to show that he has read and knows of the need of work, or that it is in progress. If in doubt he investigates the matter and either cancels or approves it.

After each job order has been completed it is filed under its proper heading, one set in the office and the order in the engine room. The file is convenient, giving information, such as the last cleaning of some particular boiler, etc., etc.; there is no poring over the daily log sheets to get this. It is ready for you in the index under its proper heading. Material used and other data is also put on these orders.

The one doing the work signs the order when complete, which, becoming a part of his record, tends to stimulate interest in the plant, as it shows the attention given by the different employes to the need of repairs.

The job orders are not numbered consecutively, but are simply dated, and the name of the work is written at the heading.

TREATING WATER at 200 deg. F. will enable one to begin with water containing 17.97 grains of incrusting matter per gallon and secure water with zero hardness, causticity 1.8 and alkalinity 6.7 grains per gallon.

—F. F. VATER.

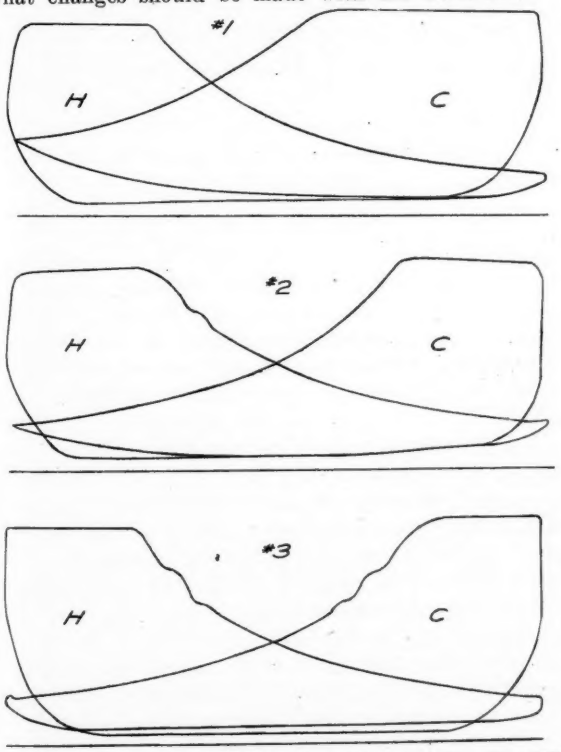
LETTERS DIRECT FROM THE PLANT

Cash Paid For Ideas Accepted. Sketches Desirable.
We Make The Drawings

Card Criticism; Piston Rings

THESE CARDS were taken with an 80 lb. spring, from a 20 by 36-in. Corliss engine, running 100 r. p. m. And No. 1 shows steam admission late at both ends, a late exhaust valve opening at crank end, and also higher compression there. The crank end cutoff was very much longer.

Card No. 2 was taken after the governor rods were adjusted, equalizing the cutoff. The reason this was done was to enable the operator to determine better what changes should be made with the eccentrics.



CARDS FROM CORLISS ENGINE SHOWING STAGES IN THE PROCESS OF SETTING VALVES

Card 3 was taken after both steam and exhaust eccentrics were moved ahead, valve rods adjusted and governor rods changed, equalizing the cutoff.

A knock in a crankpin box which was quite loud when card No. 1 was taken had almost disappeared with card No. 3.

On page 130, Jan. 15 issue, in the answer of O. H. H. to the question "What precaution would you take before and during the time you are putting new rings onto a piston?" I would also advise, in addition to the excellent answer given, that the sharp corners of the rings be slightly rounded with a file. A sharp corner on a packing ring has a tendency to scrape the oil off the cylinder wall, whereas if the edge is rounded better lubrication is assured. Also before placing rings on the piston, put them in the cylinder and see that the ends of the ring, where it is cut, do not join together, but that there is some room for expansion. This may vary from 1/16 in. in an 11 or 12-in. bore, to ¼ or 3/16 in a larger—a 28 or 30-in. bore.

Lastly, before springing the snap rings over a solid piston, be sure to have the rings hot; this lessens the liability for the rings to break. When the cast iron is cold, it is easily broken; but a temperature of 200 deg. or so works wonders. It is well to lay the rings in boiling water to heat. TOM JONES.

Starting Condensing Engine

REFERRING to the letter by O. H. H., in the issue of Oct. 15, and the comments by Mr. Magnus in the Feb. 15 issue, I would suggest still another way of handling condensing engines, which works excellently. An exhaust gate valve is installed between the engine and the condenser, the connection to the atmospheric relief valve being taken off between the engine and the gate valve. The engine is started noncondensing, that is, exhausting to atmosphere, during which time the relief valve is left open, permitting free passage for the steam to atmosphere. After the engine is thoroughly warmed up and drained, it is thrown over to the condenser by opening the gate valve, the atmospheric relief valve being first closed and the disks allowed temporarily to play upon their seats while the main exhaust gate valve is being opened. The condenser air and circulating pumps having previously been started, there is a good vacuum in the condenser, which takes the load at once. As soon as the vacuum reaches the atmospheric relief valve, it holds the disks to seat, and the operation is completed.

In order to use this method successfully, however, it is necessary to have a good atmospheric relief valve which will not hammer and injure the seats and thus give rise to air leakage. The ordinary single disk valves are not sufficiently steadied, and the rubber composition face and brass disk are quickly destroyed by this treatment, the more so as the rubber is deteriorated by being exposed to steam at 212 deg. F. and to the cylinder oil in the steam.

Lately an improved multiport type of valves has come into quite extensive use, in which a number of small disks are used instead of one large disk, each disk being held to its seat by an individual dashpot. A pressure plate permits of holding all the disks off their seats

during the free exhaust period. This pressure plate is raised and lowered by means of a screw spindle passing through a nut in the plate. The spindle can be operated by a hand-wheel on the engine room floor, or if at a distance, by means of a chain and chain wheel, an electric motor, or hydraulic pressure. Provision is made for water sealing the disks, although ordinarily it is not required, as, due to their small size, they are not distorted so much by heat as larger disks would be, and they are not injured by any hammering action.

Where a single-ported valve is used, with a large heavy disk, there is usually a great drop in vacuum at the moment when the main valve to the condenser is

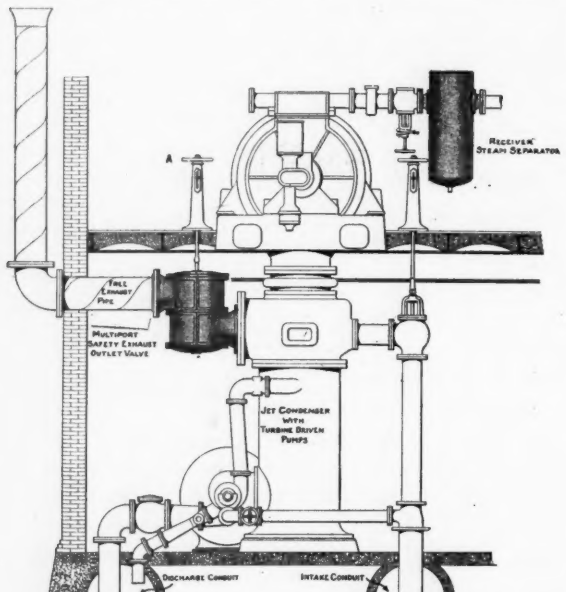


DIAGRAM OF JET CONDENSER PIPING

opened, and a certain volume of air is drawn into the condenser before the disk can seat. With jet condensers, this is extremely objectionable, especially where the condenser must operate with a high injection lift, and in many cases the throwing over is a difficult and hazardous proceeding, since the drop in vacuum due to the drawing in of air through the large single-disk valve at the moment of opening the gate valve may be sufficient to cause the loss of the injection water, and considerable experience and judgment on the part of the operating engineer are required in order to adjust the atmospheric relief valve, the main exhaust gate valve and the injection valve so that the throwing over can be accomplished with minimum damage to the relief valve, and without losing the injection water. Loss of injection water entails starting all over again, and considerable consequent delay, as the rush of steam into the condenser will have warmed it up so that pumping out by means of the air pump will be a longer and more tedious operation than at first.

The accompanying sketch shows a Westinghouse-Leblanc jet condenser outfit connected up to be operated in this manner. WM. B. CAMPBELL.

Results of Tests Using Sawdust as Fuel

WITH THE hope that some of my fellow engineers will let us know what they are doing with sawdust and hog fuel, I give a brief but rough test of one plant on Puget Sound, where the lumber industry is largely carried on. I would like to give an accurate test but have not as yet been able to get one. After having used sawdust and hog fuel for several years, I do not think it would be possible after saving approximately 75 per cent in our fuel bill, to influence the management to change back to fuel oil.

We used previously an average of 3000 gal. of oil in 24 hr. and ran constantly, and from these figures we are able to make the following comparison:

Duration of time taken for tests, 12 hr.

Previous average oil consumption, gallons, 1500.

Present average wood fuel per hr., 274 cu. ft.; 23 lb. gross to cu. ft., or 6300 lb.

Lb. of water, measured, fed by feed pump, at 202 deg., 35,136.

Lb. of water evaporated per lb. of fuel fed, 5.57.

Horsepower developed, 35,136 ÷ 34.5 = 1018.

Rating at 12 sq. ft. heating surface to boiler horsepower, 4938 ÷ 12 = 411.

Percentage of rating developed, 247.

Average temperature of superheated steam, 400 deg.

Temperature of feed water, 202 deg.

Temperature of flue gas at base of stack, 495 deg.

Number of boilers, 3 return tubular.

Size of boilers, 72 in. by 18 ft. each.

Number of tubes, 110 3-in. by 18 ft. each.

System of feeding fuel, a chain link conveyor from an enclosed hopper to dutch ovens which measure 5½ ft. by 5½ ft. by 4 ft., giving a grate surface of 30.25 sq. ft.

A fan is used to give an extra forced draft through air ducts under the usual grate bars for the purpose.

Labor necessary for the boilers is one fireman, who has charge of conveyor engine; once in a while he has to start the fuel going when lodged in the hopper.

Weight of fuel per cu. ft., 23 lb. gross.

Per cent of moisture, 52.

Pounds of dry fuel, 3024.

Heat value of dry fuel, 8500.

Pounds of water evaporated per lb. of dry fuel, as measured by feed pump, 11.6.

Number of superheaters in use, 3.

Machinery running using steam at time of test:

About 9000 ft. 1¼-in. steam coils on 4 separate retorts during the 12 hr.

30-kw. generator for light.

Well water pump, 6 by 10 in.

Feed pump, 6 by 10 in.

Large air compressor (2 hr.), 26½ by 16 in., and 18½ by 16 in.

Fire pump, 10 by 14 in.

Heating system for employes' lodging.

13 hp. vacuum pump.

Being a timber preserving plant you can realize the amount of steam we use an hour when running full.

I do not claim these as accurate figures, but they are close enough to give a conservative idea of what is possible to be done with sawdust and hog fuel largely being wasted throughout the country. My desire is to get what information possible from other engineers who have been using this fuel and perhaps have accurate results with a sketch of the system used.

M. A. THOMAS.

Oil Burning Plants

IN THE issue of Feb. 15, I notice the Comments on Oil Burning Plants, by J. M. Row. I believe that the manufacturers of our oil burners recommended that the temperature of the oil be kept at about 130 deg. F., and with the heater furnished we sometimes have trouble keeping it as high as that, especially in cold weather, when the oil is cold, and is being used faster. In the summer, when we can do so, we run it as high as 160, but I have been unable to notice much improvement, and as our oil flashes anywhere above 60 deg. C. (140 deg. F.), generally about 64, I do not think it is advisable to run it too high.

I have talked to some of the oil men of this country, and a representative of one of the largest firms stated that there were more plants getting an evaporation of less than 12 lb. of water to the pound of oil than there are getting above it. I also have great faith in the allowances, as figured at Washington; they generally are none too large.

The cost of the electricity manufactured at this plant for the fiscal year ending June 30, 1916, counting all there is that makes the difference between what Mr. Row calls the "military" way, and the way it would have been figured in a commercial plant, is about 3.18c per kw.-hr., which I don't think is so bad, considering that the average load for the year was about 29 per cent of the rated capacity of the plant.

I still maintain that the handling of the dampers on an oil burning boiler is the principal thing. Of course I know that the flues must be cleaned, in fact, our tubes are blown every morning, but proper manipulation of the dampers will help to do what Mr. Row says is so necessary, that is, keep the oil from striking the tubes or setting before it is converted to gas. Our burners are set just in front of the bridge wall, and throw the atomized oil toward the front of the boiler, and the draft carries it up through the first passage before it strikes the front wall of the setting. IRVIN O. MONTGOMERY.

Broken Gland Studs

IN THE Feb. 15 issue, C. H. W. states the trouble he has had with packing gland studs on his pump breaking, and that the trouble was stopped by turning grooves in the stuffing box.

There must have been an excessive amount of friction between the packing and the rod to cause the gland to be bent as stated, unless a very hard packing was used and the gland nuts screwed down exceptionally tight. If this excessive amount of friction did exist, the proper remedy, in my opinion, would have been to put in a softer packing with better lubricating properties to reduce the friction. It is very true that even the best packing will become hard in time, even though it does not seem to be worn out, and in order to prevent leakage the gland nuts must be screwed down exceedingly tight.

The small grooves would probably prevent the packing from moving, but could not be expected to reduce the friction between the rod and packing. In a case of this kind a few drops of oil on the rod will work wonders when the packing sticks. My remedy would have been to try a different grade of packing, one that had better lubricating properties, and more suitable to the liquid handled and pressure carried. This, I think, would have been the proper remedy. J. H. CASE.

The Boiler Inspector

I HAVE, WITH interest, followed up the article written by R. M. Packingham, and the criticism made by several different writers. The article has been criticized and mangled from nearly every point, but the boiler inspector himself has not breathed a word in self defense; he knows that it is in the game; it is an everyday occurrence to him to be criticized in some parts of his work.

It is always easier to find others' mistakes than it is to find our own, and sometimes we open our mouths too wide, without considering our right to criticize.

The man who never made any mistakes never made anything else, is an old saying, and Mr. Packingham made one big mistake when he knew that his pipe lines could be punctured with a toothpick, then waiting for the boiler inspector to condemn them, which is not part of his work.

The inspector visits the same plant only 3 times a year, and it is impossible for him to learn the conditions in the entire plant in an hour's time; he, therefore, needs the engineer's and employer's co-operation in his inspections, and if you meet him halfway and tell him your troubles, you will always find him willing to offer suggestions that may prove valuable to you.

A BOILER INSPECTOR.

Corliss vs. Poppet Valve Engines

IN REGARD to Mr. Baker's criticism of my letter on Corliss and poppet valve engines, I believe I stated clearly that the figures given were taken from reports published in the various engineering magazines at different times, and which I assumed to be correct.

There is, however, considerable difference of opinion on the poppet valve engine. For instance, one report figured the steam consumption of a certain test at 17.5 lb. per hp. hr. with superheated steam at 159 lb. pressure, and another authority using the same figures got a steam rate of about 22 lb. per hour, either or both of which may have been incorrect. From the manner of figuring, however, I considered the higher figure more nearly correct, and used it.

It is true that uniflow engines working under proper conditions may have a steam consumption of less than 17 lb. condensing at 145 lb. pressure, but it is a difficult matter to get a guarantee of less than 17 lb. for actual installations. The cross-compound poppet valve engine which I had in mind I understood was installed for the United States Metals Refining Co. in 1914. The results of the tests made were very good.

The tests of the economical German engines to which I referred were described in the engineering magazines 2 or 3 yr. ago, and were made under "the most favorable circumstances" as I stated. These low steam rates were not obtained in everyday practice, but in the testing room, and were cited only as an extreme. There is, and always will be, a difference of opinion in regard to the double beat or double seat poppet valve. Prof. Stumpf states in part regarding the double beat valve:

"Double beat poppet valves of the type used in compound engines have not proven successful with uniflow engines where steam tightness of valve is imperative. This can be insured only by making the valve as short as possible, by making one seat resilient and by balancing only to a certain amount which has to be calculated."

The lift of these valves is small and there is a greater tendency to cutting from wiredrawing the steam through them than occurs in the single beat valve which must be larger, or have greater lift to get the same port area. It is more difficult to keep the double seat valves from leaking, and when they do become cut it is more difficult to get both seats properly tight in reseating.

Another thing that must be considered concerning many of the high efficiency tests of the poppet valve and uniflow engines, is that this type is comparatively new, considering the Corliss engine and many of the favorable test figures are results of the testing floor or acceptance tests under the most favorable conditions rather than those obtained from everyday practice under the average plant conditions, which as a rule are less favorable.

But the efficiency curve is not the only thing to be considered, and there are certain conditions which in my opinion would make the poppet valve engine more desirable, such as higher steam pressure, say 175 lb. high superheated steam, or where a higher shaft speed is desirable as in direct connected generators, the speed of which has an influence on the cost. The limits of the Corliss engine in these respects are considerably narrower than with the poppet valve engine.

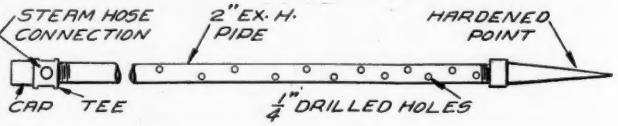
I agree with Mr. Baker that the steam consumption curves of the different types of uniflow engines will, as a rule, be more favorable than many other types; but this, of course, depends to some extent on the contitions. The original question, however, did not state these conditions, but was "Which is the more efficient, the Corliss engine or the poppet valve engine?" Nothing was said of the uniflow engine, and in considering this we are considering other things that increase the efficiency of the engine but which do not bear on the original subject, as there are poppet valve engines of the counterflow type.

J. C. HAWKINS.

Thawing Out Frozen Coal Cars; Emergency Repair for Split Pipe

DUE TO the cold weather, rains and snow, and also doubtless because of the long time the cars are in transit because of freight tie-up, the shipments of coal delivered to us have in many cases been frozen tight in the cars so that they could not be dumped without first loosening it up in some way.

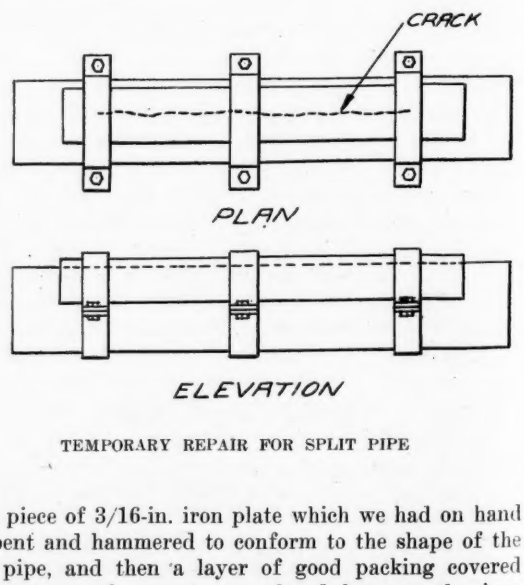
We tried prying the coal loose with picks and bars at first, but this method proved unsatisfactory in many ways. We then hit on the scheme of thawing out the coal by means of steam, and to do this as quickly and economically as possible we made several thawing bars, as illustrated, each being made out of a length (about 5 ft.) of extra heavy 2-in. pipe, drilled with a number of ¼-in. holes at the lower end, where was also placed a sharp point made by a blacksmith. At the upper end was first placed a tee, and about this a cap, and into



STEAM POINT FOR THAWING OUT COAL

the side of the tee was entered steam through hose line, and the method of operation was to drive the bars into the coal at various points by striking with a sledge on the cap at the upper end. Then when all the holes were submerged, the steam was admitted through the hose, whence it was delivered down through the pipe and out into the coal, thawing it out as was desired. By making use of 3 or 4 of these bars at a time, we could quickly loosen up the coal through the car and thus save considerable time and labor in unloading.

During a recent cold spell, a 3-in. water pipe, running between two of our buildings, froze up during the night and split for a distance of about 20 in. Not having any 3-in. pipe on hand, and not having time to make any other changes or repairs, we placed a patch over the split somewhat in the manner illustrated, and as it is still holding tight, it will probably carry us over until the entire plant can be shut down for repairs.



TEMPORARY REPAIR FOR SPLIT PIPE

A piece of 3/16-in. iron plate which we had on hand was bent and hammered to conform to the shape of the 3-in. pipe, and then a layer of good packing covered with waterproof cement was placed between the iron plate and the pipe, all of which was then clamped tightly in position by means of 3 iron straps held together with bolts. It did not take more than ½ hr. and kept the portion of the plant depending on this water supply in operation with the minimum delay. M. A. SALLER.

Questions Answered and For Answer

Expert Help When In Trouble. If You Want Quick Answer Enclose a Stamp

Examination Questions from Massachusetts

GIVE DATA for setting valves on a Corliss engine to run condensing.

2. How can the speed of a Corliss engine be changed?

3. Explain a hydraulic elevator system with open and with closed tanks.

4. What is the longest range of cutoff with the ordinary single eccentric Corliss engine?

5. What is the longest cutoff range for a double eccentric Corliss engine?

6. What are the valve positions and how determined for a double eccentric Corliss engine?

7. Is a Corliss valve balanced?

8. Could an engine connected to a condenser get water from the condenser if the condensate pump stopped and the vacuum breaker failed to work or was too small?

9. On which side of the crankpin does a connecting rod with a solid end take up?

10. If valves on a Corliss engine were open 1/8 in. at each end with the wristplate central, will the engine ever get in a position where it will not take steam at both ends?

11. If a Corliss engine is running condensing and you should add a condenser, what changes would you make in the valve adjustment?

12. With steam pressure and speed remaining the same, how would you make a Corliss engine develop more power?

ANSWERS

For a Corliss engine running condensing, the amount of lap and lead to be given the valves depends upon the size of the engine, being about as follows:

SIZE OF CYLINDER	LAP OF STEAM VALVE	LEAD OF STEAM VALVE	LEAD OF EXHAUST VALVE
18 by 36 to 22 by 40	3/8 in.	1/16 in.	1/16 in.
24 by 48 to 28 by 56	7/16 in.	3/32 in.	3/32 in.

2. To increase the speed of a Corliss engine, change the length of the horizontal rods extending from the governor to the releasing mechanism so that cutoff will occur later in the stroke. To decrease the speed, the length of the same rods should be changed in such manner that cutoff shall take place earlier in the stroke. A change in the speed of the governor, causing it to run slower will also increase the speed of the engine, or if the speed of the governor is increased it will cause a reduction in the speed of the engine.

3. The power producing mechanism of a hydraulic elevator consists of a cylinder and piston, the piston being connected by a rod, or rods, to a crosshead which carries suitable sheaves over which runs a system of lifting cables from which the car is suspended. By means of suitable valves, and controlling mechanism operated from the car, water under pressure, from compression, gravity tank systems, or from street mains where sufficient pressure is available, is caused to flow into, and out of the cylinder, thus causing the piston to move from one end of the cylinder to the other, and back again.

This motion of the piston and crosshead to and fro imparts motion to the lifting cables which pass over sheaves at the top of the elevator hatchway, and which hold in suspension the car, thus moving it up or down according as the water flows into or out of the water cylinder. The motion of the piston transmitted to the cable is multiplied to a greater or less degree by passing the cable over sheaves designed for the purpose.

In the open tank system, the water pressure averages about 150 lb. per sq. in., requiring large size water cylinders, the diameter being 16 in. or more, with a 6-in. supply pipe, while with the closed tank system in which the water pressure is 700 or 800 lb. per sq. in., a water cylinder 6 in. in diameter, having a 2-in. supply pipe would exert as much lifting power as would the 16-in. cylinder with 125 lb. pressure.

4. From the beginning up to one half of the stroke.

5. About 7/8, or 11/12 of the stroke. Just before the steam valve on the opposite end picks up for lead.

6. Set the wristplate central and clamp them in place. The lengths of the rods should be adjusted so that the steam valves are open 11/32 in., and the exhaust valves are lapped 3/16 in. During this adjustment, the reach rods should be disconnected from the wristplates. After setting the valves as above, with wristplates central, release the wristplates, connect up the reach rods, and with the eccentrics loose on the shaft, place the crank on one of the dead centers and roll the steam eccentric around far enough to give the steam valve on that end 1/32 in. lead, and make it fast. Now move the engine around in its direction of rotation to about 95 per cent of its stroke, and move the exhaust eccentric around on the shaft until the exhaust valve on the same end is just beginning to open, or release. Make the exhaust eccentric fast, and move the engine around its full revolution and check off the valves on the other end, and the exhaust closure.

7. It may be termed a semi-balanced valve.

8. Yes, with a jet condenser. The danger would not be so great with a surface condenser, for the reason that the condensing water does not mingle with the steam in the latter type.

9. Usually on the side towards the piston, in which case the tendency is to increase the length of the rod.

10. On Corliss engines with 2 eccentrics, the steam valves are adjusted so that when the wristplate is central both steam ports are open from ¼ to 11/32 in., depending upon the size of the engine; therefore, if the steam eccentric has been properly set and secured, the accident mentioned could not happen. But on a single eccentric Corliss engine the steam valves instead of giving any opening to the ports when the wristplate is central, have, or should have from ¼ to 9/16 in. lap, depending upon the dimensions of the engine; therefore, if instead of this lap, they are set so as to have both steam ports ⅛ in. open when the wristplate is in its central position, the result will be that when the engine is at the extreme of either stroke with the wristplate connected up, the steam port for that end will have an opening equal to the lap plus the ⅛ in. opening it had when the wristplate was central.

This on a 30 by 60 engine, in which the steam lap should be ½ in., would equal ½ plus ⅛ = ⅝ in. The result of this arrangement would be too early admission due to the fact that the port would have a large opening before the piston had completed its return stroke, or the crank had passed the center. The engine will take steam, but it will be at the wrong point in the stroke, and the result will be that less power will be developed.

11. If the valves have been correctly adjusted for running noncondensing, no changes need be made in their setting for running condensing.

12. Give the engine a later cutoff by changing the length of the rods which connect the valve cranks with the wristplates. W. E. ALDRICH.

Combustion of Fuel

IS IT an accepted fact that a white flame and the absence of smoke indicate complete combustion of fuel in the furnace?

2. Is it true that the products of the combustion in the furnace of a steam boiler (or any other furnace) escaping up the stack are of no value?

3. What has been the greatest evaporation of pounds of water per pound of coal fired, quality of coal, 14,500 B.t.u.'s?

4. To get an intelligent statement relative to the value of oil fuel when compared with coal, how many B.t.u.'s are there in a ton of oil?

5. Has there been a test indicating the number of pounds of water evaporated per pound of oil fired?

C. S.

ANSWERS

THE ANSWER to the first question is "no." The reason can probably be made clear by a brief outline of what a flame is, and the factors which control its color and visibility.

Flame is a mass of intensely heated combustible gas. It is not necessarily gas in a state of combustion, for combustion cannot take place without access of air, and flame may exist, as in passing through a furnace or flue, where there is no supply of air to burn the gas. If the flame in passing through a tube becomes cooled below a bright red heat, the gas will not burn when it escapes and comes in contact with cool air, but will be chilled and pass off as unburned gas and smoke.

The flame of pure hydrogen gas is almost invisible, but visibility and color may be given to it by the presence of other substances; thus carbon will make it white, copper green, cyanogen purple, and sodium yellow.

The white color of the flame of hydrocarbon gas, such as that from a candle or that of a kerosene lamp, is due to intensely heated particles of carbon. If the flame is caused to impinge on a cold surface, some of these particles will be deposited as soot.

Visible flame is evidence of imperfect combustion or non-combustion. The product of the perfect combustion of carbon is invisible carbon dioxide gas, and that of hydrogen is invisible vapor of water.

Absence of smoke is not evidence of complete combustion for the reason that carbon monoxide, a product of imperfect combustion, will pass off as an invisible gas.

2. Yes and no may be given in answer to this question, and so we shall endeavor to follow through a particular phase of the question.

This is an instance where the products of combustion (flue gases) are of more value as regards so much temperature as needed to provide draft for the furnace than when utilized in heating the boiler. The gases escaping up the chimney do possess heating value, but as the heat escaping provides the draft, the operation might be termed a "necessary evil."

3. As far as we have been able to secure reliable data, the value of 12.08 lb. of water per pound of dry coal is the highest evaporation yet obtained.

4. Fuel oil is commonly assumed to possess an average heating value of 19,000 B.t.u. per lb. It is further usually assumed to have a specific gravity of 0.90, giving 7.57 lb. per gal., and 315 lb. = 42 gal. = 1 bbl. Based upon this assumption, the following table may be of service in showing the relative values of oil and coal:

Coal, B.t.u. per lb.	1 lb. oil = lb. coal	1 bbl. oil = lb. coal	1 ton coal = barrels oil
10,000	1.9	598	3.34
11,000	1.727	544	3.68
12,000	1.583	499	4.01
13,000	1.462	460	4.34
14,000	1.357	427	4.68
15,000	1.267	399	5.01

From this table we may conclude that if the coal with the heating value of 10,000 B.t.u. per pound cost $3.34 per ton, and coal of 14,000 B.t.u. cost $4.68 per ton, then oil will be the cheaper, if it is below $1.00 per barrel.

5. In tests recorded by C. E. Felton in the Transactions of the A.I.M.E., Volume XVII, in raising steam in two 100-hp. tubular boilers, with feed water at 160 deg. F., the average evaporation with oil as fuel was 12 lb. of water per pound of oil. The maximum value obtained was 16 lb. of water per pound of oil. W. P.

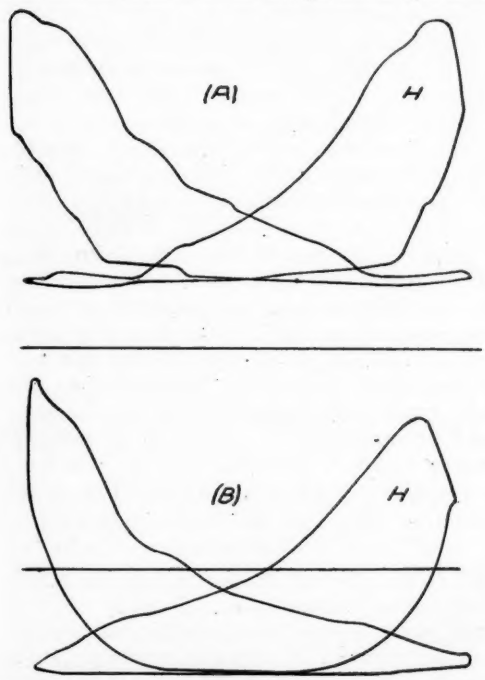
THE PROJECT of a canal connecting the Danube and the Rhine is about to take tangible shape. It is understood that the Bavarian government will soon introduce in the chambers a bill providing for the construction of a canal capable of accommodating vessels of 1200 tons. The work will cost $150,000,000, and it is estimated that it will occupy 8 yr.—Chicago Commerce.

Problems For Discussion By Readers

What Would You Do If You Had These Conditions To Meet?

Indicator Cards for Criticism

THE 2 INDICATOR cards shown herewith were taken from a condensing Ball tandem compound steam engine running at 276 r.p.m. A is from a 9-in. high-pressure cylinder and B from a 16-in. low-pressure cylinder.



INDICATOR CARDS TAKEN FROM BALL TANDEM COMPOUND ENGINE

I wish some of the readers of Practical Engineer would submit their criticisms of these cards.

S. G. M.

Corliss Valve Lubrication Trouble

RECEIVER suggests the following as probable causes for the trouble P. H. W. is experiencing as outlined on page 206 of the Feb. 15 issue: Although the oil is of a good quality, it may not be of the proper grade for that particular service; the point of introduction may be at too great a distance from the surface to be lubricated; the oil may be introduced too near the cylinder, preventing sufficient atomization; the steam coming from the boilers may carry particles of dirt and grit into the cylinder or it may contain considerable moisture.

If P. H. W. feels the cause of his trouble may be due to the use of oil not suited for the lubrication of Corliss engine cylinders and valves, J. H. Case suggests taking up the matter with the oil salesman, stating to him just what the trouble is, informing him as to the conditions under which the oil is to be used and requesting trial supplies of the different grades of oils handled for that purpose.

"The oil," he continues, "should enter the line (vertical if possible) at least 2 or 3 ft. above the cylinder to insure being thoroughly atomized and thereby be better distributed to all parts of the cylinder and valve chambers. In some instances, the cause of insufficient lubrication has been found to be due to the oil running down the inside wall of the pipe and finding its way to the exhaust without performing its proper functions. Possibly due to the use of collars on the outside to hold the tee heads away from the bonnets, P. H. W. has caused the valves to be pushed hard against the back bonnets where there may be little or no lubrication."

IF P. H. W. WILL MELT up some beeswax and give his troublesome valves a good coating of this he may obtain the results he is striving for. J. C. LEE.

How Can this Leak be Repaired?

I HAVE a direct-expansion brine tank coil made up of 1½-in. pipe and fittings and wish to know how I can repair a leak in this coil where it runs close to a partition.

What kind of pipe do you use?

Would you employ a gasket or a ground joint?

Would you use litharge on threaded joints?

H. L. H.

Low Water—What Would You Do?

DUE TO the great number of lengthy answers received in reply to the questions of C. S. W., page 206, Feb. 15 issue, we find we can publish only abstracts of these embodying the most important points brought out.

IF THE water can no longer be seen in the glass, open the bottom valve or cock. If the discharge is a mixture of water and steam, put on the feed and bring the water level back to normal.

Should this discharge contain no water, however, cover the fire, check the draft and allow the boiler to cool down, when, unless the fusible plug is blown, water may again be fed into the boiler. In the event the plug has blown, stop the pump if it is running, cover the fires and check the draft.

After the boiler has cooled, examine the upper tubes (in the case of a return tubular boiler) to see if any of them have become overheated and are sagging. If so, renew the damaged ones at once. Replace the fusible plug and restore the water line to the running level,

fire the boiler and cut it onto the line as soon as the required pressure has been attained.

Should the water be found low under the conditions stated above and the plug not blown but the pump stopped, start it. RECEIVER.

IT WOULD BE impossible to give the proper instruction which would apply to each individual case of low water, or water out of sight in the gage glass. But the safe rule to follow, and used by the operators in this plant is immediately to check the fires by closing all source of draft, and ascertain by the use of the try cocks if the water is below the lowest one. If so, the fires are immediately extinguished by fire extinguishers fitted in the furnaces, or, if this is not possible, then wet green coal is heaped on, or wet ashes, if available. By no means are the fires allowed to be hauled until they are deadened. The safety valves are raised very carefully to relieve the pressure at the moment the boiler stop is closed. Close the feed checks and stops. Stop up all air leaks to the setting around the furnace and ash pan doors, and allow the boiler to cool down under these conditions. It does so slowly, and this cooling will anneal any heated parts. Never allow any attempt to restore the water level when the water has been lost from sight, even if for only a minute, no matter whether the pump is running or not.

With a very hot fire going under the boiler, and not enough water to absorb the heat, distortion of the boiler heating surface, destruction of the bridge walls and other brick work, warping of the casing, and attendant danger of serious steam and water leaks, as well as danger of explosion, are bound to result if these precautions are not followed. C. H. WILLEY.

IT IS HARD to advise the best course to take in such a case, as reliable authorities upon the subject give advice which, to say the least, is at great variance. For instance, the Hartford Steam Boiler Inspection and Insurance Co. gives the following instruction.

"In case of low water, immediately cover the fire with ashes or fresh coal, close the ash pit doors and leave the fire doors open. If gas or oil is used as fuel, shut off the supply from the burners. Don't turn on the feed under any circumstances, and don't open the safety-valve nor tamper with it in any way. Let the steam outlets remain as they are. Get your boiler cool before you do anything else."

According to this, it is very evident that the feed water should not be admitted; the theory being that the overheated plates, when subjected to the rapid cooling effect of the feed water, contract so quickly that great local stresses are set up which have a tendency to rupture the plate.

On the other hand, C. E. Stromeyer, at the time chief engineer of the Manchester Steam Users Association, in his 1915 report to the association says: "No hesitancy should be observed in admitting feed water into an overheated boiler for the purpose of cooling it."

Also, the Steam Boiler Inspection Department of Saskatchewan, Canada, in a bulletin published several years ago, gives the same advice, that is, "Shut the draft damper, open the fire door, and start the feed pump or injector."

This advice is so contrary to the established belief as to appear ridiculous to some, upon first consideration. But is it? Admitting that a boiler overheated at any point is in a dangerous condition due to the stresses set up between the expanding heated portion and the relatively cool portions still in contact with the water or not directly affected by the furnace temperature, it follows that in order to relieve these stresses the overheated portion must be cooled to the temperature of the rest of the boiler, and it seems reasonable to suppose that the more quickly the heated portion is cooled, the quicker the danger of fracture due to the unequal expansion will be removed.

As the standard specifications of the American Steel Manufacturing Association require that steel boiler plate material shall be capable of being heated to a cherry red, cooled in water and then bent double without fracture, it looks reasonable that the old idea of the danger of rapid cooling is groundless.

In general practice, it is the writer's opinion that the course usually followed by the average attendant in the majority of cases, is to start the feed water when he finds the gage glass empty, as it seems to be a human failing to take a chance rather than take the trouble and criticism accompanying the first mentioned method. Perhaps it's a good failing after all in this case.

A. C. MCHUGH.

IN CASE of low water, first blow down the gage glass drum and try the cocks. It is always possible that the glass is not showing a true condition. If this fails to show water in the glass, the fire should be drawn at once. The condition of the pump or any of the steam valves should not be altered at this time. As soon as the fire is removed, the ash pit and furnace doors should be closed, to prevent cold air striking the boiler plate, and setting up internal strains.

Should this be one of a battery of boilers, it will be automatically isolated as soon as it ceases to generate steam, provided it is properly equipped with a non-return valve. If not so equipped, now is the time to do so.

If the pump is running, the boiler will soon fill up unless it has sprung a leak; but before the fire is started again, a close examination should be made for leaks and bags. Unless the boiler is found to be normal in every respect it should be given a hydrostatic test before going back into service. J. M. ROW.

IN CASE of low water, I would open the flue doors to determine whether the fusible plug had blown and to examine the tube ends for leaks and other possible damage, cover the fire if any signs of weakness are in evidence and cut the boiler out when it has cooled off.

If this part of the boiler appears in good order, turn to your water column and note whether all connections are proper and in good condition; then blow down water column, after which look down toward the bottom of the gage glass for signs of water. If you can see water, I would consider it safe to bring the water up to its normal level; if you cannot see water, cover or dump the fire.

Do not open or close any steam, feed or blowoff valve or valves before you are sure of conditions inside the boiler. Also be sure that the brickwork and boiler are fairly well cooled before cutting the boiler off the line. C. M.

IF THE WATER disappeared from sight in the gage glass of one of a battery of boilers and the pump was running, I would blow down the water glass, and if that did not show any signs of water I would look at the nigger head to see if that was open, as sometimes someone is apt to catch the chain and shut it off. If that was all right I would look the blow-down valve over, then open the feed valve, place my ear to it, see if I could hear the water going in, then open the pet cock on the gage (steam gage) and see that the blowoff valve is shut. If I could not get any water there, seeing that everything was all right, I would cut the boiler out, to prevent burning the boiler.

I think I would do the same if the pumps were not running, as outlined above; after trying everything that should be tried I would cut the boiler out, that is, if we could not feed the boiler with the city line or an auxiliary pump. If I could not get any water any way, I would have to cut it out for the safety of the boiler.

In case of a single boiler, I would see if the pump was running, or start the injector or open the feed valve if city pressure was sufficient, and see whether the water was going in or not. If the water was going in, I would blow the gage glass, as sometimes scale gets in the pipe if they are not blown down regularly; if that didn't work, and I could hear the water going in, I would close the nigger heads and take the water glass out and then open them up and see that no scale or mud got in there. If I could not get water into the glass and there was a check valve next to the boiler, I would shut the pump down or shut the feed water off, and take the feed valve off and see that it was all right. If I could not get water in the glass then, I would cut the boiler out and find the trouble; while doing all this looking around I would be letting the fire burn down so that I would not burn the boiler. W. DAVENPORT.

Oil Separating and Filtering Methods

IN REPLY to the inquiry of F. O. B., page 1041 of the Dec. 15 issue, I would like to describe the method I employ to reclaim engine oil.

I obtained a 10-gal. grease can, a steam coil, a pipe notched at its lower end and a funnel ½ full of white waste; these I assembled as in Fig. 1.

The can contains about ⅓ water and when the oil coming through the funnel fills the can about ¾, steam is allowed to pass through the coil, the oil is boiled for about 1 hr. and is then permitted to settle for at least 5 hr. After the oil has been drawn off the water will be found to contain a surprisingly great quantity of dirt and foreign matter.

After this oil becomes unfit for the generating units, I have reused it with ½ the quantity of new oil, with perfect satisfaction; I have also used it as taken from this filter in high-speed stoker engines.

This simple thing may appear to many as unfit for such service, but I have found that it does the work; it cost me approximately 50 cents.

In Figs. 2 and 3 are shown drawings which I found in my scrap book. I do not recall where or when I obtained them; but as the names of L. B. Gilson and J. W. Dickson appear on the original sketches, I am willing that these gentlemen receive proper credit.

Figure 2 is an oil separator. In passing through G, the exhaust steam strikes baffle F and, as a consequence, the entrained oil is caused to flow downward through H to plate D into the separator. When the water and oil rise to a level above the top of siphon 1, the water will be caused to discharge into funnel C until that in the separator falls below the level of the discharge pipe;

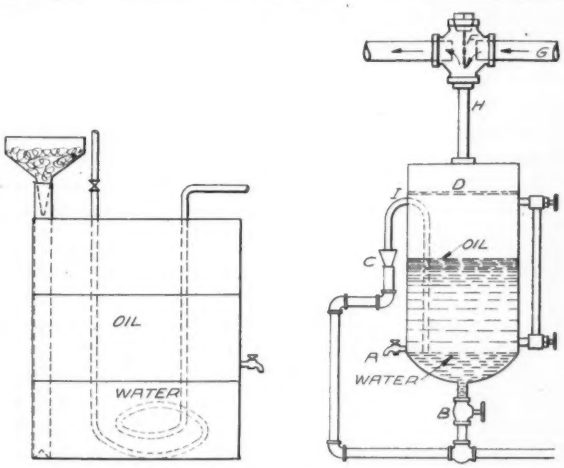


FIG. 1. A READILY AND CHEAPLY CONSTRUCTED FILTER
FIG. 2. AN OIL SEPARATOR WHICH DISCHARGES THE WATER AUTOMATICALLY

it will then refill and the process will be repeated. To remove the oil, open drain B, thus allowing all the water to flow out of the separator; close drain B and open valve A through which only oil will then flow.

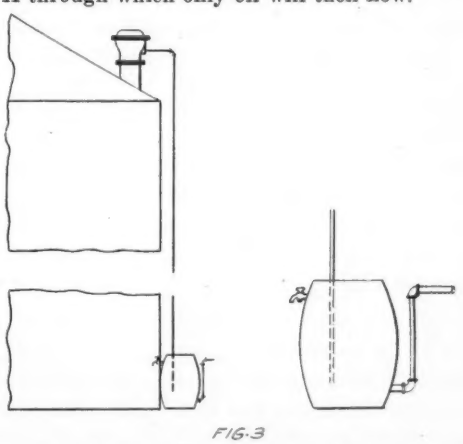


FIG. 3. BY RUNNING THE DRAIN OF THE EXHAUST HEAD TO A BARREL THE OIL MAY READILY BE RECLAIMED

Oil may be reclaimed from exhaust heads by running the drain to a barrel on the ground as in Fig. 3. The water will discharge through the connection provided for the purpose and the oil may be removed through a faucet near the top of the barrel.

Figures given with this drawing indicate that if the exhaust head has sufficient area, 50 per cent of the oil used may be saved when the engine exhausts into a closed heater, and 10 per cent when it exhausts into an open heater. J. C. LEE.

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Improving the Small Independent Plant

In a recent newspaper article, E. G. Connette, president of The United Gas and Electric Corporation, states the following advantages that come to small public utility companies through their control by a big holding company. Leaders in this field of activity watch each new invention and study the methods of other companies to find where improvements in equipment and operating practice may be made. Because of the greater opportunities open in the larger organization, experts can be hired and developed and their success in one company utilized in other subsidiary companies. Specialists in one branch of operation may be employed at the central office and their services put at the disposal of all the smaller companies controlled by the holding company, thus making available to all, advice and experience that none of those companies, acting independently, could afford to secure. Large purchasing powers make possible savings in buying of standardized equipment for all the small plants.

There is truth in these arguments that cannot be overlooked, and it is, therefore, worth while to consider whether there is any way in which the small plant, not connected with a holding company may secure some or all of these benefits gained by the large organization.

Practically all new inventions are described and the success of their operation reported in the journals devoted to power plant practice, so that, with the exception of patents controlled by the big holding corporations, no plant manager need lack this information. And the same holds good of all important advances and improvements in methods of operation. From all plants the information is gathered and is available to every reader at nominal cost, so that no ambitious engineer or superintendent has reason for being behind the times in these matters.

As to advice and experience of experts—where do they get their experience and their ability to give wise advice? Certainly, if it is based on good sense and scientific facts, the advice must rest on what has been done successfully in other plants or on experiments which demonstrate physical laws, and their proper application to plant practice. Record of such achievement is always made in the technical press and the results given in detail. And the papers before engineering societies and editorial columns are full of the scientific information which points the way to coming developments.

As an instance, the economy of forcing boilers far above rating to carry peak loads, rather than installing capacity to carry those loads at normal rating and holding the extra boilers banked during low load periods has now become widely known and largely put into practice. Yet 14 yr. ago, this economy was pointed out by the editor of Practical Engineer, and the practice urged.

For securing assistance in special problems, and overseeing of current operation, the services of independent consulting experts are always available at reasonable cost; or several neighboring plants can readily combine to control the time of a specialist in any branch of operation for so long as he may be needed.

Taking into account all these facts, the advantage of a plant controlled by a holding company does not appear essential, provided only that the responsible head of the small independent plant is alive to his opportunity and responsibility and is ready to use the means for advancement and improvement that are easily available if he will make the slight effort needed to use them.

Editorial Comments

THE WINDSOR-CANTON TRANSMISSION LINE, one of the most important engineering undertakings carried to completion during the past year, is one link in a great enterprise to supply industries located some distance from the coal fields with power direct from mines. It is described in considerable detail in the leading article of this issue. The construction work was carried on rapidly and with unusual success, due largely to the systematic methods of handling the materials. Each tower in itself is a structure carefully designed to meet severe strains and prevent interruption of service. This is the first large enterprise of its kind and familiarity with the details of the transmission line as given here is essential to an appreciation of the problems encountered in long distance transmission.

FEED WATER CONTROL has to do not only with the methods of controlling the inlet of water to the boiler, which phase of the subject was taken up in the two previous articles upon this subject, but with devices for giving warning when the water level is approaching the danger limits. The article in this issue, therefore, deals largely with high and low water alarms, giving essential details which will aid operators in caring for these important appliances.

ECONOMIZERS have been the subject of discussion for a good many years, but their place has now been quite definitely established as pointed out in this issue by Mr. Morgan, who also gives some formulas and curves to aid in determining what saving may be expected by the installation of economizers.

COAL AND ASHES HANDLING AND STORAGE is a feature of power plant design which affects, vitally, the economy of operation and in this issue Mr. Edsall points out how by a careful study of conditions and selection of equipment much expense may be saved in the original cost.

GENERATOR CONTROL has been a matter of development; from the crude hand operated rheostat employed with the first generators we have passed to finely adjusted automatic instruments that will maintain a generator voltage without perceptible variations. In the series of articles which start in this issue will be given detailed descriptions of the mechanisms and operating principles of these instruments for generator control. Here is an excellent opportunity to develop your knowledge of electric current generation.

WHY DIDN'T THE GENERATOR GENERATE? is the question put by Mr. Bava-Adam; he also answers it, but there are several points raised that are worthy of thought and discussion by readers who are invited to give their views.

THE JOY OF LIVING means, by contrast, according to Castalia, the fear of killing an electric circuit. If you think you have troubles, read about his, it will probably be like a spring tonic to you.

INTERCOOLER EFFICIENCIES are not as thoroughly understood among power plant men as the subject deserves and readers of Practical Engineer will appreciate the efforts of Mr. Richards to point out the economies gained by the use of intercoolers and the influences that affect the efficiency.

HOW POWER AND HEATING RECORDS ARE KEPT is the explanation of the solution of an important problem in an isolated plant. The subject is really inexhaustible, but a study of the record forms given here may aid you in bettering your own records.

LETTERS DIRECT FROM THE PLANT, selected for publication in this issue, deal with problems vital to the successful operation and economy of power plants. You may not agree with all the statements of the contributers; some question may be debatable; if you are wrong you want to know why; if you are right others should be given the benefit of your opinions based on experience or sound reasoning. You are neglecting an opportunity to advance, if you do not read and take part in the discussions presented in these pages.

QUESTIONS ANSWERED AND FOR ANSWER will interest you, as they take up problems met in every-day work and in examinations. Particularly valuable are the answers to the questions on combustion, one of the most important yet frequently neglected processes in the power plant.

PROBLEMS FOR DISCUSSION in this issue deal largely with that question "low water" and you will probably be surprised at the variation in opinion of those who discuss the problem. What is the problem with which you are struggling? Don't you want the help of other readers of Practical Engineer?

AFTER A LONG series of traction tests on earth and gravel roads, the U. S. Department of Agriculture recommends the following widths of tire to be adopted by manufacturers and uses for wagons of different carrying capacities: For 1-horse wagon, 2000 lb. gross weight, loaded, 2 in.; light 2-horse wagon, 3500 lb. gross load, 2½ in.; medium 2-horse wagon, 4500 lb. gross load, 3 in.; standard 2-horse wagon, 6800 lb. gross load, 4 in.; heavy 2-horse wagon, 7500 lb. gross load, 5 in. The conclusions on which this recommendation is based are shown in Circular 72 from the office of the Secretary of Agriculture.

IN THE Deutschland, the submarine which demonstrated the possibility of under-water cargo traffic, two 6-cylinder engines are installed with cylinders 15.9 in. by 19.65 in. (40 by 50 c.m.), running at ordinary operation at 380 r.p.m., as stated by Mr. Kleis, the chief engineer. Compression is to 42 atmospheres, or 620 lb. at the time when fuel is injected into the cylinders. Speed can be varied from 200 to 400 r.p.m., the fuel injection valve being adjusted while the engine is not running.

Power Apparatus in Shop and Market

New Ideas In Making, Buying and Selling

Bristol's Automatic Temperature Controllers

IN THE field of temperature measurement as applied to industrial works and manufacturing plants, the logical steps are: First, to measure and indicate the temperature with a reading instrument. Second, to record automatically the temperature with a graphic recording instrument. Third, to control automatically the temperature.

At this time manufacturers are endeavoring to use automatic apparatus wherever possible, thus eliminating the personal element and there is a demand for automatic temperature controllers in many processes already.

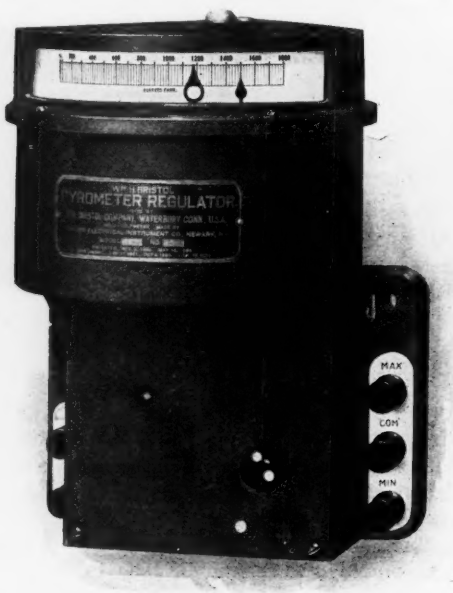

FIG. 1. EXTERNAL VIEW OF MEASURING AND CONTROLLING ELEMENTS OF TEMPERATURE CONTROLLER

The Bristol Co., of Waterbury, Conn., has developed a comprehensive new line of automatic temperature controllers for gas and oil fired and electrically heated furnaces.

The principle of operation of the new Bristol temperature controllers is to employ 3 elements: The measuring element, the contracting element and the operating element.

The measuring element consists of a number of different types of Bristol electric pyrometers and thermometers; notably the Bristol thermo-electric pyrometer with Weston millivoltmeter movement and patent Bristol separable couples, also the Bristol vapor-filled type of thermometer, which is very extensively used for recording temperatures.

The controlling element is combined with the measuring element and consists primarily of a patented electrical contact closing device, which operates at predetermined high and low temperatures, and by means of this electrical circuits are closed or opened, thus energizing or disconnecting the operating element.

The operating element consists of the device which actually regulates the heat supply in the furnace; as for instance in the case of a gas fired furnace, a pair of electrically operated gas and air valves, and in the case of an electric furnace it consists of a special relay switch opening and closing the circuits of the heating element of the furnace.

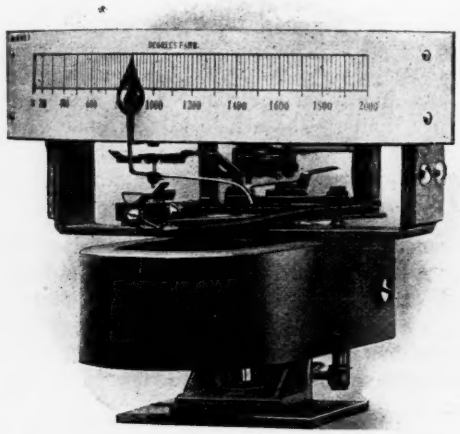

FIG. 2. INTERIOR VIEW OF CONTROLLING ELEMENT

Construction of the new Bristol temperature controllers may be seen by reference to the accompanying illustrations.

Figure 1 shows an external view of the measuring and controlling elements of the thermo-electric type, and Fig. 2 is an interior view of the controlling element, from which it may be seen that the indicating arm is completely insulated from the operating circuits. The contacting device is absolutely frictionless.

These thermo-electric temperature controllers can be furnished for all temperatures up to 3000 deg. F., and with high resistance movements for use either with base or precious metal couples.

These temperature controllers are needed for a great variety of applications and may be adapted to hundreds of processes where similar instruments are already being used successfully for measuring and recording temperature.

Potentiometers for Temperature Measurement

THE most accurate and reliable method of measuring temperature in parts of electrical machines inaccessible to thermometers, is by means of a thermo-electric couple. The practice of building such couples into the windings of large machines at points of highest temperature, though of comparatively recent origin, is fast becoming standard.

For measuring the temperature at a point where a thermo-electric couple has been installed, a potentiometer is utilized. This instrument balances the electromotive force of the couple under test against that of another couple at known temperature. By using a dial switch, any number of thermo-couples on one machine or on several, can be read at will with one potentiometer at any desired location.

WESTINGHOUSE PORTABLE POTENTIOMETER FOR "HOT SPOT" TEMPERATURE MEASUREMENT

The potentiometer shown herewith in portable is also made for switchboard use, and combines in one case all necessary parts with the exception of the thermo-couple circuit; the scale range is 0-150 to 0-200 deg. C.

The potentiometer case contains the "cold" couple which is in contact with the bulb of a mercury thermometer, by which the temperature of the cold couple is observed. A dry cell furnishes current to a resistance wire of which there are 2 sliding contacts. The drop of potential between these contacts is proportional to the current in the wire and to the distance between them. A graduated scale and 2 pointers which move with the contacts indicate the position of the latter. Scale divisions on the millivolt scale are of equal width and are numbered to read direct in millivolts. Divisions on the temperature scale are spaced according to the electromotive force law of the couple. A rheostat in the battery circuit is used for adjusting the current to the exact value that will cause a drop of electromotive force per degree on the temperature scale equal to the thermo electromotive force per degree in the couple. Leads from the thermo-couple connect through a sensitive galvanometer to the slide wire contacts of corresponding polarity. If the electromotive force between the contacts is equal to the thermo electromotive force, there will be no deflection of the galvanometer. If, however, the electromotive force is higher or lower, there will be a deflection of the galvanometer in one or the other direction. By changing the distance between contacts, using the galvanometer as a guide, the position at which the slide electromotive force balances the thermo electromotive force is easily located. One galvanometer serves both for measuring the current in the slide wire, in which case it is connected in multiple with a shunt, and for indicating balance, when it is connected directly in series with the couple.

A simple operation suffices to measure the temperature at the point where the thermo-electric couple has been installed. The electromotive force of the thermo-couple is proportional to the difference in temperature between the cold couple and the hot one. The indication on the scale, however, is the actual temperature in degrees of the hot couple, as the setting of the lower pointer on the scale at the temperature of the cold couple (indicated by the mercury thermometer) mechanically adds this temperature to the potentiometer measurement. A simple method of checking the apparatus is to make a direct comparison with a standard thermometer by placing the test couple, furnished with the apparatus, in an oil bath with a standard thermometer and comparing the potentiometer readings with thermometer readings.

These instruments are made by the Westinghouse Electric & Mfg. Co.

STATEMENT recently printed that the Babcock & Wilcox Co. had adopted Diamond Soot Blowers as standard equipment for all its boilers is liable to some misinterpretation. From information by the company it is found that the Babcok & Wilcox Co. are offering and recommending this equipment with all boilers, but does not include it as standard equipment.

FEDERAL AID for good roads will, according to Secretary Houston of the Department of Agriculture, be awarded to the different states without regard to the particular kind of material to be used, as any construction, even an earth road, provided it be substantial in character and suitable for the traffic needs, may be approved by the Department and given assistance. No barriers will be placed in the way of states which wish to avail themselves of Federal aid in road construction.

INVESTIGATION of erosion on steam turbine blading at the U. S. Naval Academy by blowing steam at 100 lb. pressure through expanding nozzles into 27-in. vacuum and allowing the jets to strike against the blading, showed that extruded brass stood up the best, with Monel metal second and steel third. Rolled brass, cupro-nickel and Parsons metal did not make a favorable showing as compared to the two first named.

The steam used was 87 per cent dry and the jet velocity about 3400 ft. per sec. Other tests will be conducted in future with varying qualities of steam and superheat.

News Notes

H. A. HOFFMAN, formerly with the General Electric Co. (steam flow meter department), has been placed in charge of the Philadelphia branch office of the Lagonda Co., with office in the Pennsylvania Bldg.

GEORGE ROSS, senior partner in the Ross Valve Mfg. Co. of Troy, N. Y., died on Feb. 9 in his eighty-eighth year, leaving his three sons, William Ross, J. C. Ross and Adam Ross 2nd in active charge of the company's affairs.

THE INTERSTATE MACHINE PRODUCTS CO., Rochester, N. Y., is the new name assumed by the Interstate Machine Co. of that city. For many years the company has specialized in the manufacture of automatic lubricating devices, but the addition of other automatic devices to their present line of products makes the broader corporate name more desirable. Fred Buckley continues as general manager and no change is made in directors or stockholders.

THE ROTO CO. announces that it has secured the services of J. D. Cherry as sales manager to take charge of the sales organizations and selling of Roto tube cleaners throughout this country and abroad. Mr. Cherry has been selling Roto tube cleaners and other steam economy devices from Chicago for the past few years and he brings to this larger field of activity a long and successful experience and the well-wishes of a multitude of friends and business associates.

AFTER MARCH 15, the Louisville branch of the H. W. Johns-Manville Co. will be located at the corner of Fourth Ave. and Guthrie St., Louisville, Ky., in the new building erected by the Speed Realty Co. This building provides a frontage on Guthrie St., which is in the very center of the retail district of Louisville. A. H. Voigt will be in charge of this office and will have under him a corps of salesmen who in these new and large quarters will be able to give even bigger and better Johns-Manville service to the buying public of Louisville and surrounding country.

THE FOLLOWING-NAMED U. S. Civil Service examinations will be held on April 11, 1917: Agricultural inspector, Philippine Service (men only); Aid, Bureau of Standards (men only); Aid, Lighthouse Service (men only); Apprentice fish culturist, Bureau of Fisheries (men only); Assistant observer, Weather Bureau (men only); Assistant photographer, Departmental Service (men only); Bookkeeper, Departmental Service (men only); Computer, Nautical Almanac Office and Naval Observatory (men only); Draftsman—Architectural, Supervising Architect's Office; Draftsman—Copyist, Navy Department (men only; Draftsman, Topographic (men only); Enginer, Indian Service (men only); Engineer, first class, steam, Departmental Service (men only); Junior Engineer (mining), Bureau of Mines (men only); Library assistant, Departmental Service; Postal clerk, Panama Canal Service (men only); Press feeder, Government Printing Office (women only); Press feeder, Hydrographic Office (men only); Scientific assistant, Department of Agriculture; Statistical clerk, Departmental Service; Teacher, Indian Service; Trained nurse, Indian and Panama Canal Services.

Application forms and full information may be obtained by addressing the U. S. Civil Service Commission, Washington, D. C.; or the Secretary of the Board of Examiners at the following-named places: Post Office, Boston, Mass.; Philadelphia, Pa.; Atlanta, Ga.; Cincinnati, Ohio; Chicago, Ill.; St. Paul, Minn.; Seattle, Wash.; San Francisco, Cal.; Customhouse, New York, N. Y.; New Orleans, La.; Honolulu, Hawaii; Old Customhouse, St. Louis, Mo.; Administration Building, Balboa Heights, Canal Zone; or the Chairman of the Porto Rican Civil Service Commission, San Juan, Porto Rico.

U. S. CIVIL SERVICE COMMISSION announces an examination for civil engineer and superintendent of construction, on March 21 and 22. A vacancy in the Quartermaster Corps, Schofield Barracks, Hawaii, at $1500 a year, and future vacancies requiring similar qualifications will be filled from this examination. The applicant must show that he has had at least 5 yr. experience in architectural construction and its supervision on the ground and in civil engineering. Graduation in engineering or architecture from a recognized technical school will be equivalent to not more than 4 yr. of the 5 required. Applicants must have reached their twentieth birthday on the date of the examination. Apply for Form 1312.

U. S. CIVIL SERVICE COMMISSION announces an examination, March 20, for engineer of tests for experimental work in aero motor engineering. A vacancy in the Department of Steam Engineering, Navy Yard, Washington, D. C., at $4000 a year, and future vacancies requiring similar qualifications will be filled from this examination. Competitors will not be required to report for examination at any place, but will be rated on general education and technical training, experience and fitness, publications or reports or a thesis. Graduation with a bachelor's degree in civil, mechanical, electrical, or marine engineering from a college of recognized standing, and at least 5 yr. subsequent experience in experimental or laboratory work of which time not less than 2 yr. were in a position of responsibility, are prerequisites for consideration. Applicants must have reached their twenty-fifth but not their forty-fifth birthday. Apply for Form 2118.

U. S. CIVIL SERVICE COMMISSION announces an examination, March 20, for mechanical engineer, qualified as inspector of gages. A vacancy at the Frankford Arsenal, Philadelphia, Pa., at an entrance salary of $2000 to $2400, and future vacancies requiring similar qualifications will be filled from this examination. Competitors will not be required to report for examination at any place, but will be rated on education, technical training and experience. A B. S. degree in egineering from a college or university of recognized standing, and at least 3 yr. experience in a manufactory making arms or ammunition of which not less than 1 yr. embraced the

These tables contain data especially worked out or carefully selected that are vital to your work. You may need them at any time and should preserve them. A handy, serviceable, loose-leaf cover in which these tables fit exactly, will be sent you for 30 cents in currency or stamps.

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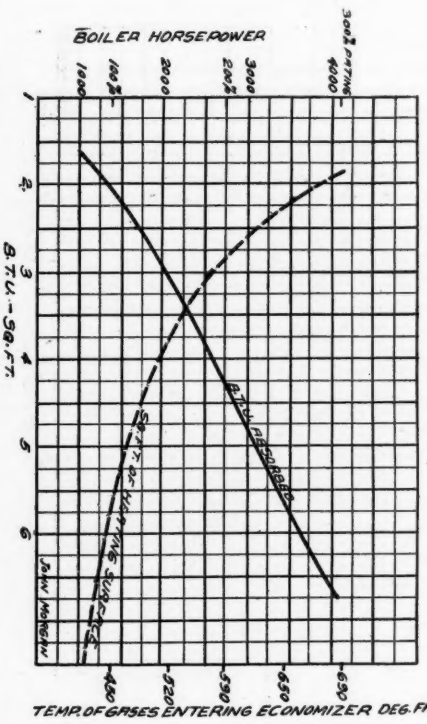
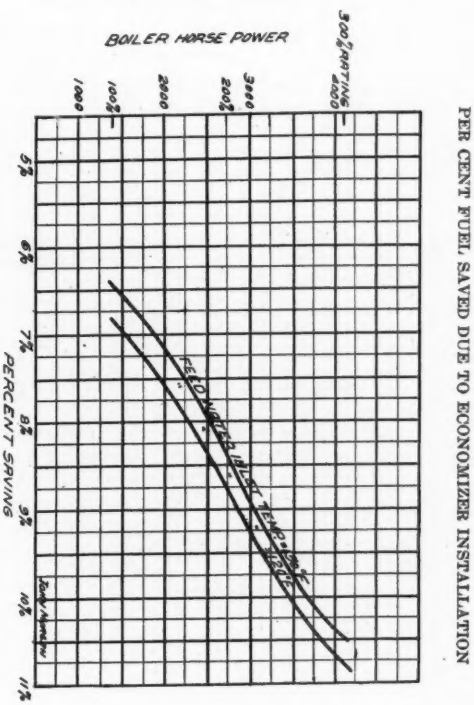
PRACTICAL ENGINEER

ECONOMIZER HEATING SURFACE PER BOILER HORSEPOWER; HEAT ABSORBED PER SQ. FT. PER DEGREE REDUCTION IN THE FLUE GAS TEMPERATURE



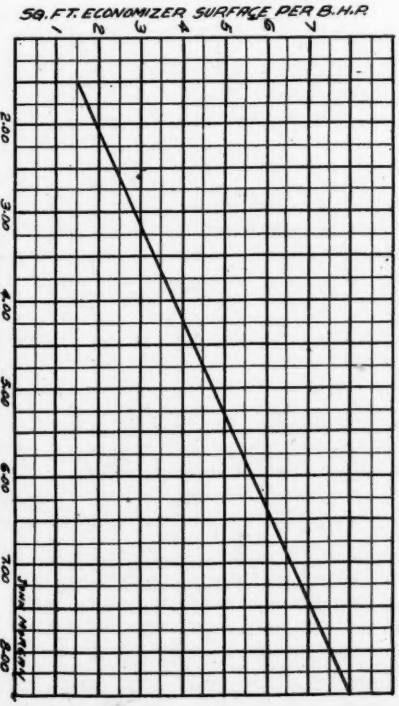
PRACTICAL ENGINEER

PER CENT FUEL SAVED DUE TO ECONOMIZER INSTALLATION



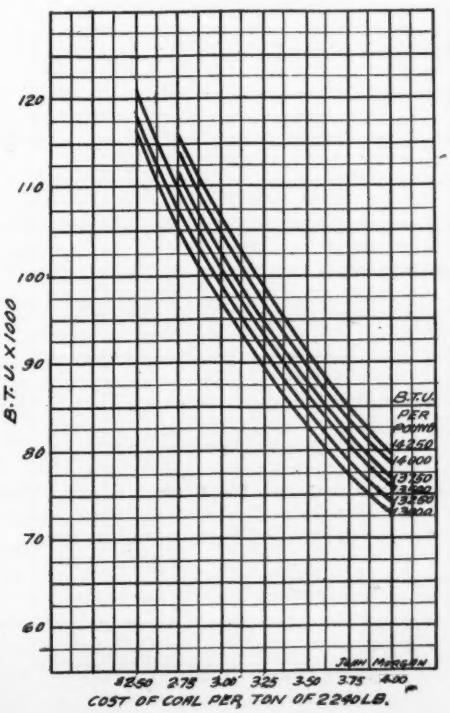
PRACTICAL ENGINEER

ERECTED COST OF ECONOMIZER AND INDUCED DRAFT FAN PER B. HP.

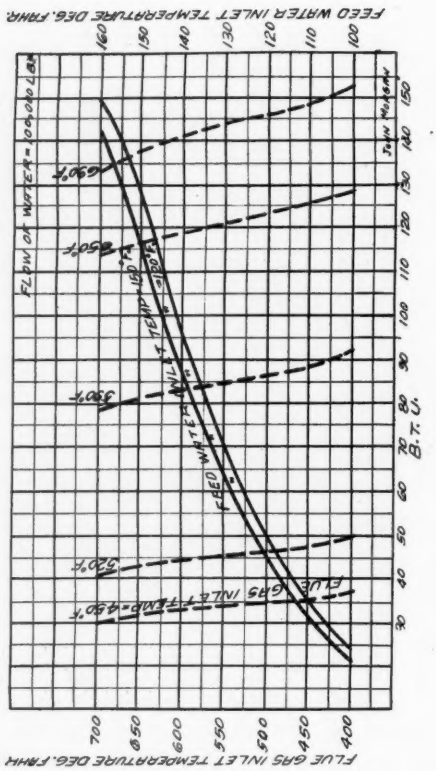


PRACTICAL ENGINEER

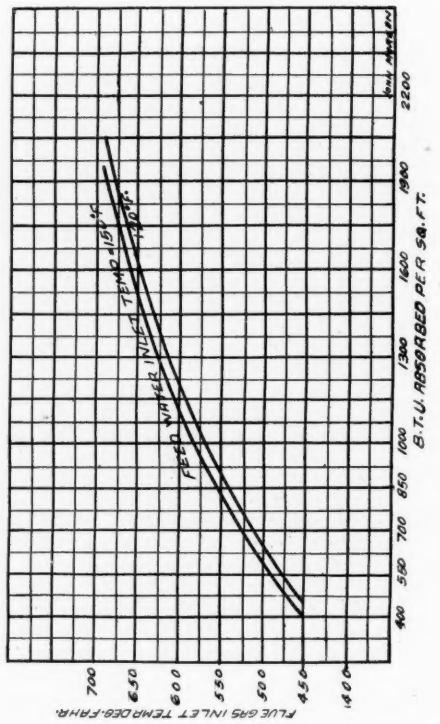
B.T.U. PURCHASED FOR 1 CENT INDICATED BY LEFT HAND SCALE TIMES 1000



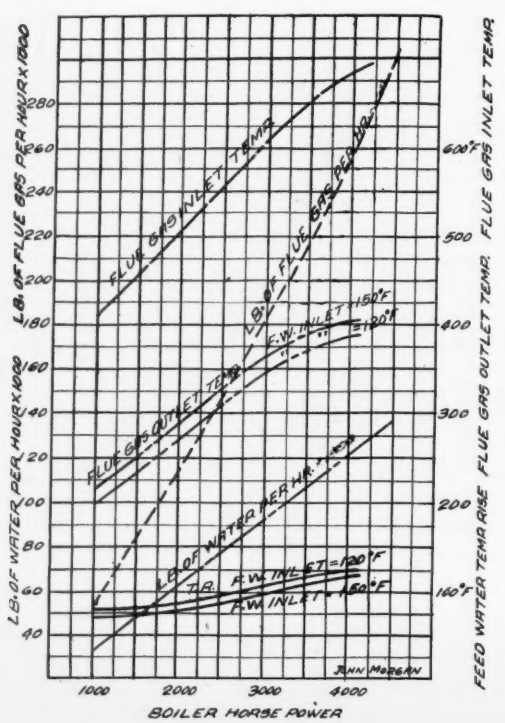
HEAT ABSORBED PER HOUR PER POUND OF WATER


FEED WATER INLET TEMPERATURE DEG. FAHR.
FLUE GAS INLET TEMPERATURE DEG. FAHR.
B.T.U.
FLOW OF WATER = 10,000 LBS.
FEED WATER INLET TEMP. 150°F
FEED WATER INLET TEMP. 120°F
FLUE GAS INLET TEMP. 650°F
John Morgan

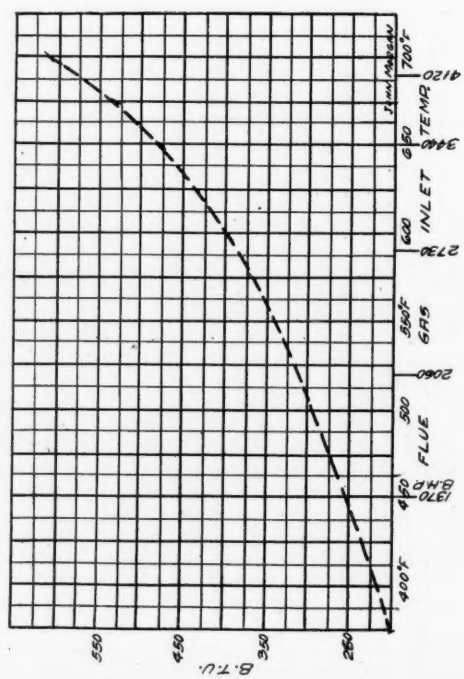
HEAT ABSORBED PER SQ. FT. OF ECONOMIZER HEATING SURFACE



OPERATING DATA FROM A 7750-SQ. FT. ECONOMIZER


LB. OF FLUE GAS PER HOUR x 1000
LB. OF WATER PER HOUR x 1000
FLUE GAS INLET TEMP.
LB. OF FLUE GAS PER LB. OF WATER
F.W. INLET = 150°F
F.W. INLET = 120°F
FLUE GAS OUTLET TEMP.
LB. OF WATER PER HR. = 10M
T.R. F.W. INLET = 120°F
F.W. INLET = 150°F
FEED WATER TEMP. RISE
FLUE GAS OUTLET TEMP.
FLUE GAS INLET TEMP.
BOILER HORSE POWER
John Morgan

HEAT ABSORBED PER SQ. FT. PER DEG. MEAN DIFFERENCE IN TEMPERATURE



duties of an inspector, enabling the applicant to acquire proficiency in the use of ammunition gages, are prerequisites for consideration. Applicants must have reached their twenty-fifth but not their fifty-fifth birthday. Apply for Form 1312.

U. S. Civil Service Commission announces an examination for junior mechanical engineer, on March 21. A vacancy in the Ordnance Department at Large, Springfield Armory, Mass., at $1000 a year, and future vacancies requiring similar qualifications will be filled from this examination. Successful completion of at least 3 yr. of study in civil, mechanical, or electrical engineering at a college of recognized standing, and 6 mo. experience in engineering work preferably along lines similar to the duties of the position or equivalent training and experience are prerequisites for consideration for this position. Applicants must not have reached their thirtieth birthday on the date of the examination. Apply for Form 1312.

U. S. Civil Service Commission announces an examination, March 27, for mechanical engineer. A vacancy at the Springfield Armory, Springfield, Mass., at $3500 to $4000 a year, and future vacancies requiring similar qualifications, will be filled from this examination. Applicants must have reached their twenty-fifth but not their forty-fifth birthday. Apply for Form 1312.

Books and Catalogs

Arithmetic for Engineers, by Chas. B. Clapham; 428 pp., 5½ by 8½ in.; 150 illustrations; with problems and answers. New York, 1916. Cloth. Price, $3 net.

This book by Mr. Clapham, who is Lecturer on Engineering and Elementary Mathematics at the University of London, is stated by the author to treat elementary mathematics in a practical manner, suitable for home study and technical schools. It begins with measurements and units and the use of mathematical signs, assuming that the reader is familiar with the fundamental operations of addition, subtraction, multiplication and division of whole numbers.

A chapter is given to vulgar fractions, explaining the different forms and how to handle them, and simplification by cancellation. Another chapter deals with decimal fractions, the movement of the decimal point, changing from vulgar to decimal fractions and the reverse, and the degree of accuracy desirable in working with decimals.

Symbols and formulas and the use of powers and roots, also the meaning and use of negative quantities are taken up in the following chapter, and the author then passes to the use of simple equations of algebraic form and how to handle them in solving problems.

Other chapters treat of transposing equations and formulas to find the value of any desired quantity; the use of logarithms and the slide rule; finding of areas and volumes of regular and irregular figures and solids; and the construction and use of curves and graphical methods for finding the relation and variation between quantities.

At all points, illustrations are freely used, problems being worked out on the dimensions of machinery and steam apparatus to show the application of the principles and methods as explained. Many problems are given for practice besides those solved in the book, the answers being collected at the back of the book for reference in checking results.

All explanations are clear and detailed, the student being taken from simpler to more difficult subjects gradually so that he can master each part with reasonable effort and make progress with certainty. The book is well adapted to its purpose, and the practical problems give interest and definite purpose to the student in his work.

High Frequency Apparatus, by T. S. Curtis; 243 pages, illustrated; first edition; New York, 1916. Price, $2.

Due undoubtedly to the comparatively limited extent to which it is employed, high-frequency alternating-current electricity is of intimate knowledge only to those having to do with wireless telegraphy and telephony, electro-therapeutics, etc. A study of these phenomena is, however, interesting and especially so when supplemented by experiment as is evident by the general demand said to have been created by a series of articles which recently appeared in Electrician and Mechanic, Popular Electricity and Modern Mechanics, and The World's Advance. It was in response to this demand that this volume was prepared and to render it of special value to the layman and non-technical reader, theory has been practically entirely ignored. The book is of a purely practical nature throughout.

The work has been divided into six basic parts. The first two chapters instruct the reader as to the nature, the method of production and the use of high-frequency currents. In the second section, which consists of four chapters, the transformer, condenser, spark gap and oscillation transformer, are described and the main points in the design and construction of these devices as applied to the work in hand considered. Section three covers the construction of small high-frequency outfits designed for experimental work in the home laboratory or the class room. The fourth section is devoted to the electro therapeutic and X-Ray apparatus. In the fifth, apparatus for the cultivation of plants and vegetables is described, while the sixth section is devoted to a comprehensive discussion of apparatus of large size for use upon the stage in spectacular productions.

An appendix giving the current prices of the parts and materials required for the construction of the apparatus described has been added with a view to expediting the purchase of the necessary goods.

GRAPHOIL LUBRICATORS, which are used to lubricate steam cylinders, gas engines, air and ammonia compressors, vacuum pumps and bearings, are described and illustrated in a circular from Graphoil Lubricator Co., 1777 Broadway, New York.

BULLETIN "D," recently issued by Mesta Machine Co., Pittsburgh, Pa., describes the Mesta Automatic Plate Valve (Iversen patent). These valves are being used very successfully in both new and rebuilt air and gas compressors, ammonia compressors, vacuum pumps and blowing engines, and the data given in the bulletin throws light on some phases of air handling.

HOVALCO angle blowoff valves in combination with Homestead quarter turn plug cocks are the subject of a circular recently received from Homestead Valve Mfg. Co., Homestead, Pa.

SUBSTATIONS FOR MINES are thoroughly described and illustrated in Leaflet 3697, just issued by the Westinghouse Electric & Mfg. Co., in which a discussion is given of the use of motor generators and rotary converters for mining work. Installation views of mine substations are shown.

BULLETINS have been received from Spray Engineering Co., Boston, as follows: Bulletin No. 15, Modern Road Construction; No. 52, Air Washers; No. 30, Spray Nozzles for scrubbing gases, settling dust, cooling air, chemical uses, spraying insecticides; No. 23, Sprays for Cooling Condensing Water; a fifth bulletin describes a spray air cleaner for home use.

Trade Notes

STROH STEEL HARDENING PROCESS CO. has established an office at 728 Monadnock Block, Chicago, with F. Lloyd Mark in charge as Western Sales Manager for the central and near western states.

DE LAVAL STEAM TURBINE CO., Trenton, N. J., manufacturer of steam turbines and helical reduction gears for all classes of service, announces the opening of a district sales office in the Smith Building, Seattle, Wash., in charge of William Pullen.

EDWARD R. LADEW CO., INC., leather belting manufacturers, are distributing among engineers an aluminum grip pencil, with extra supply of leads in a receptacle in the handle. These pencils may be had by writing to the company's New York office, 135 Center St.

THE DODGE STEEL PULLEY Corporation, a subsidiary of the Dodge Manufacturing Co., of Mishawaka, Ind., has acquired the property of the Oneida Steel Pulley Co., of Oneida, N. Y., and will immediately put into operation plans for a largely increased production of the pulleys and other products of the Oneida Co.

MILLER-COMBES CO., INC., has recently opened offices at 150 Nassau St., New York, for the sale of steam and water specialties, engineers' and contractors' supplies, pipe, valves, fittings, etc. F. J. Miller, of this company, was formerly associated with the Thos. P. Ford Co., New York.

TWENTY-SEVEN, new type, forced draft, high reserve capacity stokers of the underfeed type have been sold by the Westinghouse Electric Export Co., of East Pittsburgh, Pa., for service in Japan. The stokers are for use with 600-hp. boilers. Twenty of them were sold to Osaka Electric Light Co., 2 to the Nogoia Electric Light Co. and 5 to the Imperial Steel Co. The orders also included engines for operating the stokers, turbine and motor driven forced draft fan units, controllers, and other auxiliaries.

No better illustration of the progressiveness of Japanese concerns in changing over their power plants to the most up-to-date, high capacity equipment, could be found than what these orders indicate. By the use of these stokers, the plants are able to obtain from 2 to 3 times the capacity of the boilers.

PRACTICAL ENGINEER

Trade-mark, Reg. U. S. Pat. Off.

PUBLISHED ON THE FIRST AND FIFTEENTH OF EACH MONTH.

SEMI-MONTHLY

Subscription price in advance in the United States, Mexico or united possessions, $1.00 a year.

In Canada, subscription price, $1.75 a year.

Foreign Countries, subscription price, $2.50 a year.

Address all letters and make all checks and money orders payable to Technical Publishing Co., 537 S. Dearborn St., Chicago. Ill.

Any advertiser is invited to examine our paid subscription lists and Post Office mailing receipts at any time.

ADVERTISING RATES

Display

Full page, one year, each insertion, $66.00.

Half page, one year, each insertion, $38.50.

Quarter page, one year, each insertion, $22.00.

Eighth page, one year, each insertion, $13.25.

Front cover, $175.00 per issue.

Other specified positions, regular rate plus 10 to 50 per cent.

Stippled plates used, but no heavy, black and white plates.

Classified Rates

Per line, 30 cents each insertion.

Advertisements in this section are inserted under regular headings.

No display type allowed, but the first three words may be set in capital letters.

About nine words make a line. Minimum space sold, two lines.

Under classification "Position Wanted," advertisements not exceeding four lines will be inserted once for subscribers free of charge.

All copy should be received at Chicago office 18 days before date of publication.

Circulation of this issue, 22,000.

Technical Publishing Co.

537 S. Dearborn Street

Chicago

Position Wanted

POSITION WANTED—I am a thoroughly competent power plant engineer, accustomed to handling on high efficiency basis all types of steam engines and turbines, a.c. and d.c. machines; strictly sober; 34 years old, married. Want charge of good plant in Chicago that will pay at least $25.00 per week. Address Box 455, Practical Engineer, 537 S. Dearborn St., Chicago. 3-15-1

POSITION WANTED—By engineer 30 years old, married; 7 years' experience with Corliss and high speed engines, refrigeration and d.c. generators. Address Lee McCallum, 512 N. Park, Cadillac, Mich. 3-15-1

POSITION WANTED—As Fireman or Oiler in large plant; 3 years' experience as fireman, 18 months as assistant engineer. Married. Strictly sober. Prefer Southern States. L. C. Drake, Cambridge City, Ind. 3-15-1

POSITION WANTED—As chief engineer in industrial plant, Missouri, Arkansas, Kansas, Iowa or Nebraska, or as Superintendent of light and water plant in city of 2500 to 8000. Ten years' practical experience with steam, electrical and water systems. Technical training. Now employed by U. S. Government as engineer and instructor. Executive ability. Can report on 15 to 30 days' notice. Married. Age 30. Address Practical Engineer, Box 466, 537 S. Dearborn St., Chicago, Ill. 2-1-14

Help Wanted

WANTED—Resident subscription agents in the following cities: Atlanta, Ga.; Cincinnati and Columbus, Ohio; Kansas City, Mo.; Los Angeles, Cal.; Louisville, Ky.; Newark, N. J.; New Orleans, La.; Portland, Ore.; St. Louis, Mo.; San Francisco, Cal.; Washington, D. C. This is an excellent chance for a hustler who is familiar with power plant conditions, to turn his spare time into dollars. To such a one we offer a Real Opportunity. Write Subscription Department, Practical Engineer, 537 S. Dearborn St., Chicago, Ill. tf.

WANTED—A first-class fireman to look after twelve 150-hp. tubular boilers; one who is well up in economy in coal and understands thoroughly the care of boilers; must be sober, industrious and steady. A good position for the right man. Address Practical Engineer, Box 469, 537 S. Dearborn St., Chicago, Ill. 2-15-3

WANTED—A first-class licensed engineer to operate modern boiler plant in vicinity of Philadelphia. Must be thoroughly familiar with Sterling boilers, Taylor stokers, steam turbines, centrifugal boiler feed pumps, economizes, etc. Address Box 473, Practical Engineer, 537 S. Dearborn St., Chicago, Ill. 3-15-1

WANTED—First-class mechanic, experienced in erecting machinery. Address Box 475, Practical Engineer, 537 S. Dearborn St., Chicago, Ill. 3-15-1

Wanted

WANTED—Agents on commission to sell our shaking grates. We will install grates on trial or put it on test at our expense with any grate made. Address Armstrong Mfg. Co., Springfield, Ohio. tf.

FOUR COPIES of Practical Engineer for February, 1910, in good condition; we will extend your subscription for three months. Circulation Department, Practical Engineer, 537 S. Dearborn St., Chicago, Ill.

MARINE BOILERS WANTED—From 50 to 250 horsepower. We will pay cash awards for information that leads to a purchase. The Pittsburgh Boiler & Machine Co., Pittsburgh, Kans. 1-1-6

WANTED to purchase one secondhand alternator, 75 or 85 k.v.a., 60 cycle, 3 phase, 2300 to 2400 volts, 900 r.p.m. belted type, rev. field machine, with exciter and other accessories. Guaranteed to be in first-class operating condition. Send copy of name plate with quotation. H. E. Johnson, Supt., Senatobia Electric Light & Water Plant, Senatobia, Miss. 3-15-2

WANTED—A sheet metal smoke stack, 30 in. or 32 in. diameter, about 50 ft. high. State condition and price. Address Paul O. Moratz, Bloomington, Ill. 3-15-1

WANTED—Steam engine indicator, second hand, in A1 condition. State price and particulars in first letter. Address J. G. Burton, Frankfort, Kan. 3-15-1

WANTED—Agents handling engine and boiler room specialties in every section for side line paying large commissions. Give experience, line carried and territory covered. Box 381, Practical Engineer, 537 S. Dearborn St., Chicago, Illinois. tf.

For Sale

FOR SALE—Buckeye 120-hp. hor. single act. Tandem Gas Engine; two 28-hp. 4-cyl. Clifton Marine Engines; one 15-hp. Foos Gas Engine; 8-16 Springfield 12-hp. stationary Gas Engine. Int. Equipment Co., 517 Monadnock Bldg., Chicago. 3-1-2

FOR SALE in North Dakota town of 1000 population electric light and power plant. Twenty-four hour service. Plant in good condition. Distribution system covers entire town. Extensions well cared for. Good feed mill business in connection. Price, $30,000. Terms, one-third cash, balance to suit at 5 per cent interest. Address Box 474, Practical Engineer, 537 S. Dearborn St., Chicago, Ill. 3-15-4

FOR SALE—Two model stokers in splendid condition, only two years in use; 8 ft. furnace, suitable for 300 to 400-hp. boilers. Address Practical Engineer, Box 470, 537 S. Dearborn St., Chicago, Ill. 3-15-1

FOR SALE—100hp. Erie city boiler, return tubular, 125 lb. pressure, with feed water heating system, in excellent condition; also 50 hp. Erie City engine. Immediate delivery. Harley D. Carpenter, Meadville, Pa. 3-15-1

125 VOLT GENERATORS—150 kw. Westinghouse d.c. Fleming engine, $2000; two 50-kw. C. W. with ball engines, $1000 each; 20 kw. G. E. with ball engine, $550; 15 kw. G. E. marine unit, $550; 9 kw. G. E. marine unit, $400. Power Machinery Exchange, Jersey City, N. J.

FOR SALE—McKenzie chain grate stoker, practically new. Address A. P., 517 Monadnock Bldg., Chicago, Ill. 3-1-2

Patent and Patent Attorneys

PATENTS THAT PROTECT AND PAY—Advice and books free. High references. Best results Promptness assured. Send sketch or model for search. WATSON E. COLEMAN, Patent Lawyer, 624 F St., N. W., Washington, D. C. tf

PATENTS—C. L. Parker, Attorney-at-Law and Solicitor of Patents. Patents secured promptly and with special regard to the legal protection of the invention. Handbook for inventors sent upon request. Washington, D. C. tf.

PATENTS—H. W. T. Jenner, Patent Attorney and Mechanical Expert, 606 F St., Washington, D. C. Established 1883. I make a free examination and report if a patent can be had and the exact costs. Send for full information. tf.

A. P. CONNOR, Consulting Electrical and Mechanical Engineer, Attorney-at-Law and Solicitor of Patents and Trade-Marks. Results guaranteed. 121 Carroll St., S. E., Washington, D. C.

PATENTS — Send sketch for free search and reports. Books and patents and book of reference letters sent free. John S. Duffie & Co., 612 F St., Washington, D. C. tf.

PATENTABLE IDEAS WANTED—Send for three free books. R. B. Owen, 28 Owen Bldg., Washingon, D. C. tf.

Technical Books

FREE ENGINEER BOOKS and power plant tools and specialties, for securing new subscribers to Practical Engineer. A dandy chance for the engineer with a little spare time, to get some fine premiums. Send for free descriptive circular and terms. Subscription Department, Practical Engineer, 537 S. Dearborn St., Chicago, Ill.

Miscellaneous

ENGINEERS, DO YOU WANT to utilize your exhaust steam for heating or drying purposes without back pressure on your engine? If so, address Monash Engineering Co., 1413 W. Jackson Blvd., Chicago, Ill. tf.

Sparks From The Advertising Pages

Carlyle once said, "An education consists not so much in storing the mind with information as in studying to remember where that information can be found," or words to that effect.

Successful men in all walks of life keep a mental index of the things of interest to them. A prominent illustrator said recently, "Although I keep clippings of the thousands of things useful in my profession, the things I cannot include in my clipping collection I can lay my hands on in a short time."

It is impossible to keep a file of all the things you desire to know or will have need of in the future, but as you read and study you can fix in your mind the source from which you are getting this information and then when you want it you can go to that source.

This, of course, means a thorough and consistent reading.

Only last week a man came into the office of Practical Engineer seeking a number of issues containing a serial article on water softening. He had read the article in some other subscriber's papers. Knowing about the time in which it appeared, we found it at once. Of course, it would have been an easy matter anyway, but the point we emphasize is that this man was making an index of his brain.

What is true of the editorial contents is also true of the advertising matter. Practical Engineer contains an index to all advertisements in the current issue, but it cannot include all the advertisements that have appeared throughout the year. If you do not wish to mutilate your copy of Practical Engineer to establish a clipping file of these advertisements, you must keep an index of them in your brain.

You can recall within your own experience times when you have searched in vain for articles and advertisements. You saw the possibility of their usefulness when you first read them, but they slipped away from you somehow and a later search proved futile. In the case of advertising it is a good thing to write for literature on engineering products when their need is anticipated.

But in addition heed the advice of Thomas Carlyle and study each issue of Practical Engineer to remember where editorial or advertising information can be found.